THE ENGINEER

A Seven-Day Journal

Edmonton and Engineers

IT will be recalled that the Edmonton Borough Council recently made a condition, in the appointment of a borough engineer and surveyor, that "the person appointed shall during the term of his employment by the Council be and continue to be a member of a trade union affiliated to or specified by the Trades Union Congress or eligible for affiliation to the T.U.C. Failure to comply with this condition renders any employee liable to instant dismissal." The Engineers' Guild, as recorded in our issue of June 8th, addressed a letter of protest to the Council, copies of which were sent to the Minister of Transport and the Minister of Local Government and Planning. Subsequently, the Guild, in conjunction with the Association of Local Government Engineers and Surveyors, arranged for a question on the subject to be asked in Parliament. On Wednesday last, it was announced that the Edmonton Borough Council had withdrawn the condition. At a meeting of the Council on August 28th, a letter from the Minister of Transport was considered which stated that, unless the condition of appointment was withdrawn, the Minister would be unable to make a grant from the Road Fund towards the salary of the successful applicant. A resolution that the Council should meet the Minister's requirements was passed unanimously. As a result the position is to be re-advertised without the objectionable condition.

Second-Hand Machine Tools and the Defence Programme

LAST week seventy representatives of machine tool merchant firms from all parts of the country attended a meeting convened by the British Association of Machine Tool Merchants to explain a scheme it had drawn up in conjunction with the Director-General of Machine Tools, Ministry of Supply. In opening the meeting, Mr. W. R. Clarkson, the president of the Association, said that the response to the invitation to attend showed the keenness of the trade in its desire to support the Government in matters vital to the national interest. Mr. S. W. Rawson, the Director-General of Machine Tools, gave the meeting a detailed statement of the needs of the defence programme, and said how vital it was that his department should have available details of all second-hand machine tools in the short supply categories. The scheme drawn up by the Association gave the department an opportunity to consider each second-hand machine in short supply, and he was certain that, if operated by each machine tool merchant, it would assist considerably in achieving the requirements of the defence programme. The scheme laid down also provided for a liaison committee comprising initially seven representatives of the trade who would be available to give advice to him, and for regional panels of experts to give technical assistance locally in connection with the use of second-hand machine tools. Mr. Rawson urged the trade to operate the scheme, and if in practice there were any difficulties, he was certain that they could be overcome by discussion between the liaison committee and himself.

Shipping Taxation Memorandum

THE General Council of British Shipping, in its Taxation Memorandum to the Royal Commission on Taxation of Profits and Income, maintains that the continuance of the present system of taxation will endanger the maintenance in strength of the British mercantile marine. An efficient and prosperous shipping industry is essential for an island nation, and the memorandum points out that the seas are free to all; therefore, shipping is in open competition and must operate all its services at a competitive price, there being no protected home market. Two matters are dealt with, namely, the basis of calculation of depreciation allowances and the balancing charges on ships sold or lost. A survey shows that the replacement of war losses and the maintenance of competitive efficiency has fallen entirely on the industry, since war loss compensation was offset by high building costs. Continuing, the memorandum mentions that all industries have to meet increased costs, but believes that ship costs are higher and recalls that a ship cannot be replaced by degrees, the problem being aggravated by the high rate of tax on profits calculated without taking account of increased replacement costs. The General Council asserts that taxation allowances should allow for the amount necessary to amortise the capital cost and, in times of rising prices, the amount necessary to replace wastage of fixed capital which has occurred. This is not regarded as preferential treatment, and in the Council's view the granting of capital allowances by reference to the current value of fixed assets is essential in ascertaining taxable profits.

British Airline Reports

IN their reports for the financial year ended March 31st, both the British Overseas Airways Corporation and the British European Airways Corporation show a combined deficit of £5,544,695, compared with £9,155,481 deficit for the year 1949–50, which is, in fact, the most favourable balance to date. Contributory factors to B.O.A.C.'s improved working are stated to be the addition to its fleet of more effective aircraft; a general increase of air traffic, the passengers carried rising from 155,557 last year to 200,514, and a freight increase from 3968 tons to 5104 tons, and the reduction and general reorganisation of its personnel. The adverse balance of B.E.A.C. was reduced by 28·2 per cent to £979,267, which was also in part due to an increase of traffic of 23 per cent and to an extension of its route pattern, the whole of its loss being incurred between December and March. B.E.A.C. became short of aircraft towards the end of the year, a contributory factor being the delay in delivery of "Ambassador" aircraft, of which twenty are awaited. The report of B.E.A.C. also strongly criticises the practice of including in the price of the travel ticket free ground transport, wines and liqueurs and other free gifts. Both Corporations plan to increase the density of seating patterns with a reduction in passenger amenities in order to extend at more reasonable charges the benefits of air travel.

Technical and Scientific Manpower

ON Wednesday, August 29th, the fourth in the series of Centenary Lectures on the worker in industry, arranged by the Ministry of Labour and National Service, was given by Lord Hankey, the chairman of the Technical Personnel Committee. Lord Hankey spoke on technical and scientific manpower, and after tracing the growth of universities, technical colleges and scientific and technical institutions, he dealt with their present and their future. In their efforts to increase the output of technical and scientific graduates since the war, the universities had achieved, he said, an overall increase of 50 per cent above the pre-war number of students, and most of these were concerned with scientific and technical subjects. Technical colleges, said Lord Hankey, had also made notable advances since the Education Act of 1944, and another important educational landmark had been the establishment of national colleges for teaching a variety of technical subjects. After dealing with various aspects of the future, higher education, humanities, &c., Lord Hankey then said that he would put forward a new idea for consideration at top level—that science and technology might do well to study the Committee of Imperial Defence in setting up the Imperial Defence College, with a view to the possible adaptation of the same system, *mutatis mutandis* to the study of the science and art of higher scientific and technological administration. At the Imperial Defence College selected officers drawn from the fighting Services and civil services of Great Britain and the Commonwealth and Empire had studied together under experienced direction the broadest aspects of Imperial strategy, to the greatest advantage of all concerned. Although in science and technology there might not be so definite an objective, there was the same need for a cadre of persons qualified for higher direction and top-level co-ordination.

Productivity Report on Welding

THE Anglo-American Council on Productivity has published this week the report of a specialist team on welding, which toured the U.S.A. in October and November of last year. The team of eighteen members was led by Dr. H. G. Taylor, director of research of the British Welding Research Association, and, briefly stated, its terms of reference were "to investigate the use of welding in the U.S.A. with a view to finding out how British industrial production can be improved." The report is arranged under seven major headings dealing with mechanical handling, preparation of material for welding, welding processes and equipment, inspection and testing, working conditions, the cost of welding, and welding in particular industries. Like most of the other specialist teams which have visited the U.S.A., the members of this one formed the opinion that, in the welding industry, American productivity is higher than British. The difference may not be very great, the report says, but that should not detract in any way from the urgency of applying at home those features of the American welding industry which, if applied here, would certainly improve productivity. Among what are set out as its "important recommendations" the team suggests that managements in this country should devote serious thought to economic planning and the more generous introduction of mechanical handling devices, and that the unions, on their part, should accept freely all labour-saving devices with a realistic approach to any redundancy of manpower involved. In the course of its findings, the team has pointed out that in the U.S.A. greater use is made of mechanical aids to assist or to eliminate manpower, particularly in all aspects of handling, and that greater use is made of automatic welding machines of all kinds. It is also stated in the report that there is greater standardisation of resistance welding machines in the U.S.A., the capacity being frequently expressed in terms of the suitability for particular jobs.

The Engineering and Marine Exhibition

No. I

THE Engineering, Marine and Welding Exhibition, which incorporates the Foundry Trade Exhibition, was opened at Olympia, London, yesterday, August 30th, and will be open daily until Thursday, September 13th. In the article which follows and the Supplement accompanying this issue a number of the exhibits are described. Further descriptions of the machinery and equipment on view will be given in subsequent issues of this journal.

Harland and Wolff, Ltd.

On its stand Harland and Wolff, Ltd., of Belfast, shows a number of exhibits illustrating the activities of the company in the marine and industrial engineering fields. There is a 1 : 10 scale model of a six-cylinder, two-cycle, single-acting, opposed-piston eccentric-crosshead marine engine (Fig. 1), which develops 7000 b.h.p. and embodies "uniflow" scavenging, the air from rotary blowers being admitted to the lower pistons and the upper pistons, releasing the exhaust gases. The cylinders have a bore of 750mm by a combined stroke of 2000mm and the b.m.e.p. is 6·1kg per square centimetre. An all-welded design has been adopted for the columns, entablature and flat-bottom bed-plate, which incorporates the thrust block.

Power from the upper pistons is transmitted through eccentrics incorporated in the cast steel crank webs, and there are four side rods, one pair forward and one pair aft of each cylinder, which are attached to a yoke bolted to each upper piston. The rods extend down to crossheads on each side of the main guide. Both pistons have crowns of heat-resisting steel and flanged piston ring carriers, the upper having six rings and the lower six rings and a scraper ring.

Lubricating oil is used for piston cooling, and is fed through telescopic pipes, afterwards returning to double-bottom tanks under the engine. Cooling of the vanadium cast iron cylinders is effected by fresh water circulating between the jackets and the cylinder liners, which are so anchored that they can expand upwards and downwards. There are two fuel valves per cylinder and the fuel pumps are operated by a chain-driven camshaft. Two positive displacement blowers, driven through gearing by roller chains from crankshaft sprocket wheels, draw air in through silencers and pass it through the scavenge belt to each cylinder, suction and delivery passages being interchanged when manœuvring.

The main bearings are of white metal, steel backed, and there is forced lubrication throughout. Overhaul and maintenance at sea have influenced the design of the engine and all the main working parts can be examined with the minimum of dismantling.

Also shown is a Cooper-Bessemer combination vee gas engine and horizontal compressor unit built under licence by Harland and Wolff Ltd., which is designed to compress the various gases used in the petroleum and chemical industries. The set is illustrated in Fig. 2. and has ten power cylinders and three double-acting compressor cylinders, the power being 1100 b.h.p. at 300 r.p.m. It represents a range of gas engine and motor-driven air and gas compressors having outputs from 150 to 2750 b.h.p.

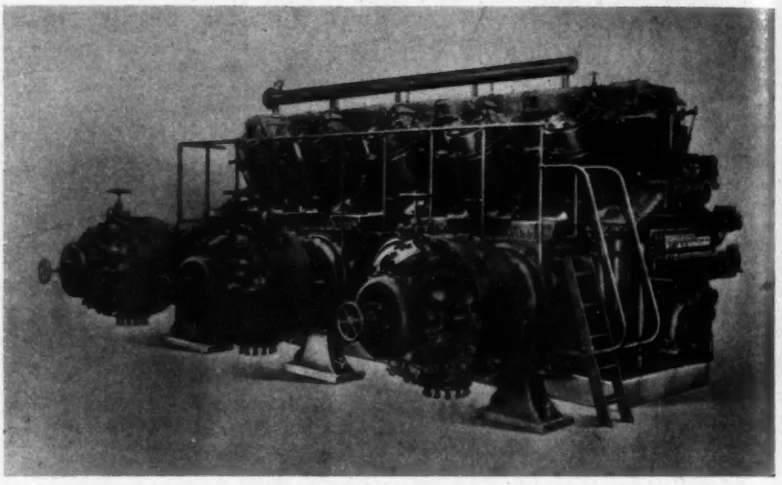


Fig. 2—Cooper-Bessemer Gas Engine and Compressor—Harland and Wolff

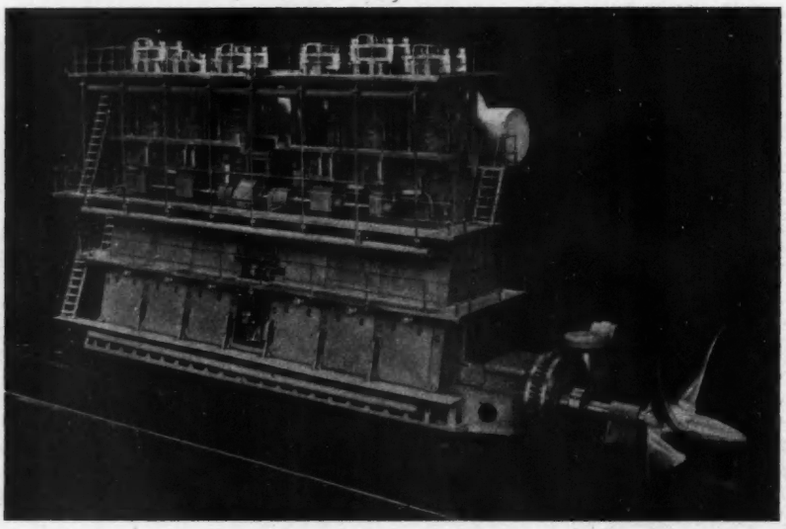


Fig. 1—7000 B.H.P. Opposed Piston Diesel Engine—Harland and Wolff

British Moulding Machine Company, Ltd.

Shown for the first time in this country by the British Moulding Machine Company, Ltd., of Faversham, Kent, is the company's new "BT" turnover moulding machine, which until recently was only available for foreign markets. These machines, one of which is illustrated in Fig. 3, incorporate a number of technical improvements, of which perhaps the most interesting is the built-in jolt timer, which enables them to be set to stop jolting after any required number of jolts. All operations are controlled by push button, and, in addition to automatic lubrication, built-in air filters and a fully automatic anvil, there are other improvements calculated to enable the machine to operate at high production speeds for long trouble-free periods. On the stand both large and small machines are shown producing moulds and, in the case of the larger size, the sand is hopper fed into the boxes.

The "B.T.I." machine illustrated has a 26in by 19in table, its jolt capacity being 400 lb, squeeze pressure 7000 lb, pattern draw stroke 8in, and squeeze adjustment 7in. Its massive column is locked rigidly on the heavy shaft carried on large plain bearings in the main trunnion housing, and this shaft with the column is turned by sprockets and roller chain actuated by a pair of hydraulic cylinders. These cylinders and chain gear are totally enclosed in the housing against the ingress of dust and sand, and "topping-up" of the cylinder is effected without need for removing the housing panels. Also fitted to the rear end of the trunnion housing is the main lubricator of the machine. With this lubricator a measured quantity of oil is admitted to the pneumatic system each time the machine is turned over.

The swing arm carried on large bearings at one end of the column is designed to remain quite rigid during the squeeze and pattern draw operations. The head of the arm is split to facilitate adjustment of the heavy threaded adjustment screw carrying the plate. It is fitted with a combined handle and locking lever, which enables the head to be swung with equal ease whether it is in the upright or the inverted position.

The jolt, squeeze and pattern draw mechanisms of the table are contained within

the main cylinder and are controlled by three "push-button" valves on the front. These valves are fitted with striking levers in order to protect them from damage. The jolt timing mechanism is housed in the column of the machine.

The jolt stroke is long and the impact is positive, and the three hardened and groun p steel guide rods which are fitted do not move up and down with the table during jolting,

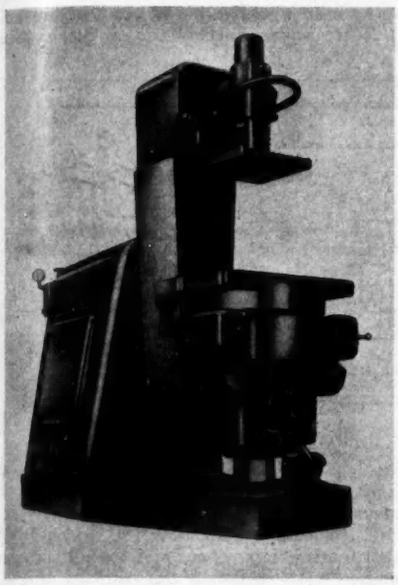


FIG. 3—TURNOVER MOULDING MACHINE—BRITISH MOULDING

but they are brought into use during the pattern draw operation. A pneumatic anvil, which automatically lifts the jolt unit during the turnover operation, allows it to rest solidly on the base-plate of the machine when jolting is in progress.

From the operator's viewpoint, control of the machine is simple. With the table in the filling position the left-hand valve lever is depressed to start jolting and when that operation is complete depression of the right-hand sets the squeeze ready for turnover. Turnover is controlled by a kick-over lever at the foot of the machine. When the table is in the inverted position, the same two levers as for jolting and squeeze are used for operating the vibrating and "slow" draw movements. A third lever is depressed at the end of slow draw to give a "fast" pattern draw.

R. A. LISTER (MARINE SALES), LTD.

Besides showing a complete range of Lister engines from 8 b.h.p. to 65 b.h.p., the main exhibits on the stand of R. A. Lister (Marine Sales), Ltd., of Dursley, Gloucestershire, are two of the new Blackstone "E.V." engines. The engines on view have six cylinders, are both normally aspirated and develop 270 b.h.p. at 600 r.p.m. One is displayed as a main propulsion unit complete with a 2 to 1 reduction gear and reverse gearbox, and the other is coupled to a 130kW generator, representing a marine auxiliary.

The engine has a bore and stroke of 8¾in by 11½in, and a compression ratio of 14 : 1, the compression pressure being 560 lb per square inch and the b.m.e.p. 86·1 lb per square inch. The cast iron, box section crankcase carries the 40 to 50 tons per square inch nickel steel forged crankshaft in Babbitt-lined steel-backed bearings. Cast iron is used for the cylinder block, while the single-unit cylinder heads are cast in nickel iron and take air inlet and exhaust valves and a central oil-fuel-injection valve. Chrome-hardened wet liners are fitted and are free to expand downwards.

The pistons of close-grained cast iron have a toroidal combustion chamber in the crown and three compression rings, one scraper ring and one oil seal ring. Circlips retain the fully floating gudgeon pin and the connecting-rods of H-section, heat-treated steel stampings have Babbitt-lined, steel-backed, big-end bearings and small-end bushes of chill cast phosphor-bronze. The cyanide-case-hardened 3 per cent nickel steel camshaft is gear driven from the flywheel end and each cylinder has an individual fuel pump which delivers fuel at 2200 lb per square inch through a six-hole nozzle. There is a dry sump and lubricating oil is pressure fed to all working parts through drillings, and there is an oil cooler.

Engine cooling is by fresh water, circulated through the cylinder jackets and a heat exchanger by a gear-driven centrifugal pump with a delivery of 2300 gallons per hour at 1500 r.p.m. A second gear-driven centrifugal pump, with a capacity of 1900 gallons per minute against a head of 40ft at 1500 r.p.m., circulates cooling water to the heat exchanger and oil cooler. For starting purposes compressed air at 250 lb per square inch is admitted to all cylinders from an air receiver of 7½ cubic feet capacity.

AUTO-KLEAN STRAINERS, LTD.

In addition to a range of its standard units and a working model of the automatic self-cleaning "Flushflo" strainer for large industrial and marine work, Auto-Klean Strainers, Ltd., of Lascar House, Hounslow, Middx., is exhibiting for the first time one of its "T.K." self-cleaning strainers. This new unit is intended for ultra-fine straining of large flows of liquids, such as in marine main line lubricating oil systems. It is a development of the standard Auto-Klean strainer with added mechanical strength in the straining element, finer straining and increased flow capacity.

The principal components of one of the elements of the improved filters and their method of assembly is clearly shown in the illustration Fig. 4. The filter pack is formed by threading alternately on a central spindle hollow metal plates, 0·010in thick, and star-shaped washers, 0·003in thick. Two sizes

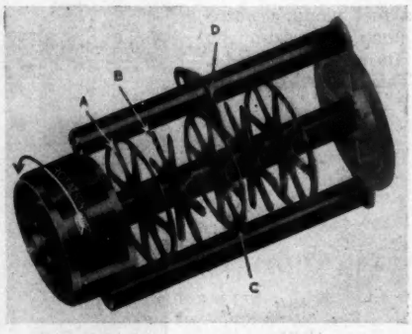


FIG. 4—FILTER COMPONENTS—AUTO-KLEAN

of plates are used, the outside diameter of the smaller being equal to the inside diameter of the rim of the larger. The sequence of assembly is as shown in the illustration—large plate *A*, spacer *B*, small plate *C*, etc. Cleaning blades *D* mounted on a support rod at the side of the pack are inserted between the rims of the adjacent larger plates and the toe of each blade rests on the periphery of the smaller plate. These 0·015in thick cleaning blades are pivoted on the ground steel support rod attached to the top cover. A smaller rod passing through and fixed to the cleaners ensures their correct alignment and free movement between set limits. As can be seen in the second illustration, Fig. 5, showing the complete casting of the strainer, concentricity of the complete element is ensured by hollow end bearings, which run in locking plates fitted on the support rods.

When the element is rotated by means of an external handle each cleaning blade

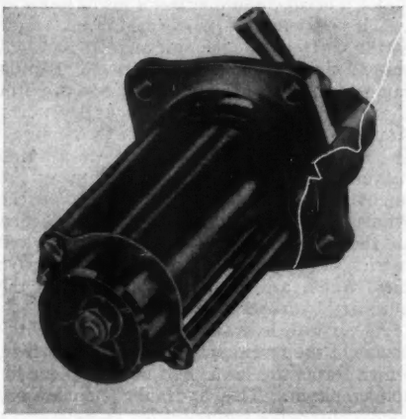


FIG. 5—FILTER CARTRIDGE—AUTO-KLEAN

removes from the sides of the large plates and the periphery of the small plate between them all solids deposited in the slot.

In operation, the oil to be filtered passes from the outside to the inside of the element. Initial fluid entry is thus between the large plates, which are 0·016in apart, and final access to the inside of the element is through 0·003in wide slots formed by the spacing washers. The makers can supply units having final access slots as small as 0·001in wide for certain applications.

ENGLISH STEEL CORPORATION, LTD.

Many noteworthy steel forgings have been produced in the works of the English Steel Corporation, Ltd., and one of the outstanding exhibits on the firm's stand this year at Olympia is a machined forged gear wheel rim, 11ft 9in diameter, weighing some 7½ tons. This ring, which has no welds or joints, was follow-forged from a solid ingot.

Another exhibit of interest is a 10ft long, 1½-ton crankshaft, forged by the "R.R." continuous grain-flow process, invented by M. Roederer, a former director of the Compagnie des Forges et Acieries de la Marine et D'Homecourt, which uses the process at its works. Under the new process a crankshaft is press forged, and although it possesses all the characteristics of a drop forging, can be of a size outside the scope of a drop forge shop plant. In crankshafts made by the new technique continuous grain flow through all sections is ensured, a minimum of machining is required for finishing purposes, crank throws are formed at the correct relative angles without twisting, and flanges may be upset, giving the correct grain flow. Sole British rights for the manufacture of crankshafts by the new process have been acquired by the English Steel Corporation, Ltd. Particulars of the process are given in a booklet published by the Corporation, and the following notes are based upon this information.

The process is described with reference to the diagram reproduced in Fig. 6, showing

the original apparatus used, which is in the form of a hydraulically operated machine, which, although it can be used on any forging press, is not an integral part of the press. The left-hand side of the diagram shows the equipment at the start of a forging operation and the right-hand side at the end of the operation.

The machine is mounted on a heavy bedplate, which can be withdrawn as required from below the press by the ordinary drawback gear. Sliding in guides on the bedplate are two members *A*, which are called cradles. These cradles carry the lower halves *B* of the dies used for gripping the crank journals, and one has a lower half die, which positions the last-formed crank throw at the correct distance and angular relationship to the one about to be formed. Sliding ramps are formed on the outer end faces of the cradles and angular projections depending from the upper tool *C* locate on these ramps. It will be appreciated that downwards movement of the upper tool acting on the angular faces of the ramps will move the cradles inwards. The upper tool is attached to the moving crosshead of the press and carries the upper halves *D* of the respective dies, which are locked in position by the auxiliary hydraulic cylinders *E*.

A vertical hydraulic cylinder *G* in the centre of the machine bed carries an anvil *H*, which forms the lower half of the holder for the crankpin. This hydraulic cylinder exhausts through a spring-loaded valve and the stroke of its ram can be preset to determine the throw of the crankshaft. The upper half holder *J* for the crankpin is carried on the top tool and, if the machine is used to upset the material for the crank webs, it is mounted on the ram of a hydraulic cylinder *K*, which has an adjustable stroke. In the cycle of operations, as the upper tool descends the ram of *J* is forced back into its cylinder until the correct amount of material to form the crankshaft web has been upset. Then, as the downward movement of the press continues, the holder moves downwards against the resistance of the cylinder *G*, forcing the crankpin down to the correct throw.

In forming a section of crankshaft, once the machine has been set and the forged bar threaded into the lower dies, the top tool descends until the holder engages the part to be formed into the crankpin and the journal dies grip tightly on the shaft beyond. As the downward stroke of the press continues the tool moves inwards and upsets the material for forming the crank webs. At the predetermined moment the upper holder cylinder pushes the crankpin holder with its supporting anvil downwards against the resistance of its hydraulic piston. During this movement the cradles continue their simultaneous inward movement until the crank webs are of the required thickness, when they automatically stop. At the same time the anvil and holder will have moved downwards the correct distance to complete the formation of the crank throw.

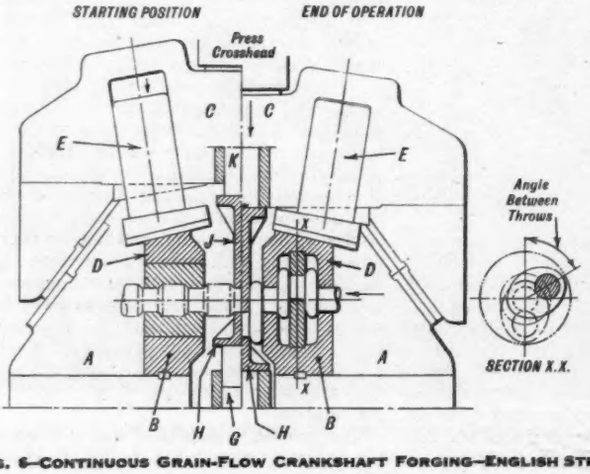


FIG. 6—CONTINUOUS GRAIN-FLOW CRANKSHAFT FORGING—ENGLISH STEEL

GRESHAM AND CRAVEN, LTD.

Together with one of its most recent models of the compressed-air-operated "Ejecto-pump," Gresham and Craven, Ltd., of Ordsall Lane, Salford, 5, is exhibiting a small automatic flash tube steam generator which it is now being built in this country under licence from the Vapor Heating Corporation of the United States.

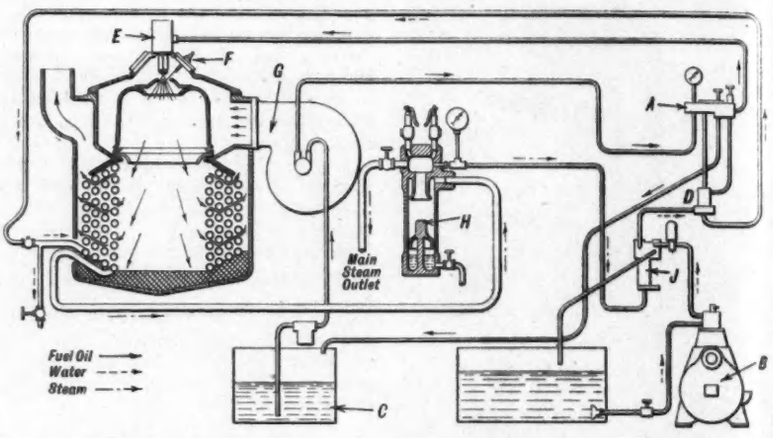


FIG. 7—FORCED CIRCULATION STEAM GENERATOR—GRESHAM AND CRAVEN

The steam generator exhibited, illustrated in Fig. 8, is one of a number being supplied for A.E.C. railcars being built for the C.I.E. Railways of Southern Ireland. It is a forced-circulation, continuous water tube unit, with a rated capacity of 250 lb of steam per hour at pressures of up to 200 lb per square inch. The fuel used in the generator is a light-grade diesel oil and the driving unit used for its operation can be a ¾ h.p. electric motor or an I.C. engine.

In the diagram we reproduce (Fig. 7) the operational sequence and circuits are clearly shown. The units are assembled on a fabricated angle steel frame and the motor is mounted on a platform at one side. Through vee belts the motor is connected to a fuel pump, a water pump, a forced draught fan and a magneto. This magneto is continuously driven and sparks all the time the unit is in operation.

When the unit is started up the fuel pump feeds oil under pressure to the manifold *A*. Until water pressure is built up in the system by the pump *B* and water starts to flow through the boiler coil, the fuel supply to the manifold is by-passed back to the fuel tank *C* through the control valve *D*. When a sufficient pressure of water is available the fuel control valve ceases to function and pressure builds up in the manifold and the spray head *E* of the boiler. At a pressure of 60 lb per square inch in the oil fuel system the atomiser valve opens and the oil spray is ignited in the boiler by the sparking plug *F*. The flame is projected downwards to pass through the coils and the burnt gases flow out of the combustion chamber to the smoke stack. Combustion air is supplied by the fan *G*.

Steam flows from the boiler to the main steam outlet through a unit assembly *H* incorporating safety valves, a separator and a pressure gauge. When a predetermined steam pressure is reached the water supply control valve *J* is actuated by a small steam line on which the pressure gauge is mounted, and this valve operates to by-pass water back to the supply tank. The drop in water pressure in the system causes the fuel supply control valve to by-pass the oil back to the fuel tank. When the steam

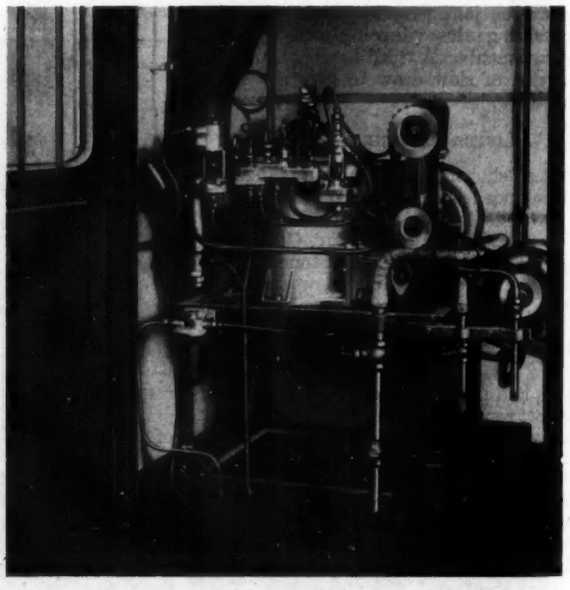


FIG. 8—STEAM GENERATOR—GRESHAM AND CRAVEN

pressure falls the water control valve closes and the increased pressure in the system restores both water and fuel oil supplies to the generator.

In full working order the unit weighs 900 lb and its fuel consumption is stated to be about 1 lb of fuel oil to evaporate 10 lb to 12 lb of water.

The construction of this firm's well-known compressed-air-operated displacement "Ejectopump" and the principle upon which it operates has already been described in the columns in connection with previous exhibitions. The unit exhibited is of the "B 2 SV" type, in which power-operated valves automatically controlled by compressed air are fitted. With these valves the pumps can be used to handle liquids containing small solid matter such as fruit stones, peas, &c.

(To be continued)

Pipe Networks

By A. W. T. DANIEL, M.A., A.M.I.C.E.

Symbols

Q = flow in gallons per minute.
l = length of pipe, in feet.
d = diameter of pipe, in feet.
h = head lost in pipe friction, in feet.
H = total head at any specified point, in feet.
q = average rate of abstraction, in gallons per minute per lineal foot.
S = area under the curve of Q^n, between two specified values of Q—for example, Q_A and Q_B.
$Q_0 = \frac{1}{2}(Q_A + Q_B)$.
K^1, K, n, and m are constants.
Suffixes refer to pipes or joints.

Introduction

IN the case of water flowing through a closed pipe, the head lost in friction is assumed to follow the law $h = \frac{K^1 l Q^n}{d^m} = KlQ^n$, where K depends on the diameter of the pipe. Where there is a network of pipes with several branches in parallel, the distribution of flow among the different branches for a given total head through the network is often a problem with mathematical difficulties which is most easily solved by trial and error. Cornish* has developed a method in which trial solutions are substituted in the equations, and the errors systematically reduced to any desired degree of negligibility.

The extension of this problem to include the case where one or more of the pipes has water drawn from it at intervals along its length has been considered,† but not apparently reduced to a precise form, and the object of this article is to outline a method of dealing with this problem based on the principle of systematic reduction of errors.

An example is a street main with houses drawing off at intervals along its length, where for the sake of simplicity it may be assumed that there is a constant loss of q gallons per minute per lineal foot of main. Consider a pipe AB (Fig. 2) with flows as indicated and a constant rate of abstraction q g.p.m./lin. ft. Take A as origin, and consider an element of length δx. Then the abstraction from the whole length $= ql$ g.p.m., and hence $Q_B = Q_A - ql$.

Also the abstraction from the element δx is $q\delta x$, and hence if the flow entering the element is Q, the flow leaving it is $(Q - q\delta x)$, which may be written $(Q + \delta Q)$, where

$$\delta Q = -q\delta x \text{ or } q = -\frac{\delta Q}{\delta x}.$$

If the head lost in friction through the element is δh, then

$$\delta h = KQ^n\delta x = -\frac{K}{q} \cdot Q^n \delta Q.$$

$$\therefore H_A - H_B = {}_Ah_B = -\frac{K}{q}\int_A^B Q^n dQ$$

$$= \frac{K}{q(n+1)}\left[Q_A^{n+1} - Q_B^{n+1}\right]$$

$$= \frac{K}{q(n+1)}\left[Q_A^{n+1} - (Q_A - ql)^{n+1}\right] \quad . \quad (1)$$

Note that if $q = 0$, then ${}_Ah_B = KlQ^n$, which is the simple case of a plain pipe.

Now consider the network shown in Fig. 1, in which pipes Nos. 1, 2 and 3 are subject to abstractions q_1, q_2, q_3 g.p.m./lin. ft respectively, but Nos. 4, 5 and 6 are plain pipes. Suppose water enters at A under a known head H_A and leaves at D under a known head H_D, and it is required to find H_B, H_C, H_E and the flows in all pipes.

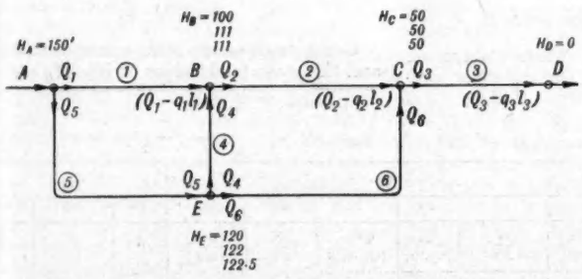


FIG. 1

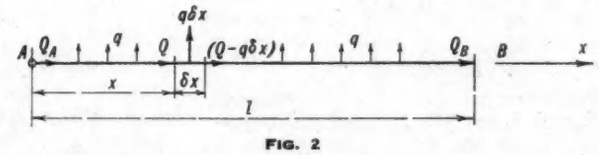


FIG. 2

Considering the three pipes meeting at B, equation (1) can be applied in each case, thus,

$$H_A - H_B = h_1 = \frac{K_1}{q_1(n+1)}\left[Q_1^{n+1} - (Q_1 - q_1 l_1)^{n+1}\right] \quad . \quad (2)$$

$$H_B - H_C = h_2 = \frac{K_2}{q_2(n+1)}\left[Q_2^{n+1} - (Q_2 - q_2 l_2)^{n+1}\right] \quad . \quad (3)$$

$$H_E - H_B = h_4 = K_4 l_4 Q_4^n \quad . \quad (4)$$

Also

$$Q_1 - q_1 l_1 + Q_4 - Q_2 = 0 \quad . \quad (5)$$

In the method now to be described, from an inspection of the network trial values are assumed for H_B, H_C and H_E, these are denoted by H_B^1, H_C^1 and H_E^1. Then, on substituting in equations (2), (3) and (4), it is possible, as described below, to obtain the corresponding trial values of Q_1, Q_2 and Q_4. On substituting these in (5), since they are not the correct values, the sum of the flows will not be zero, but will be some quantity ΣQ which may be positive or negative.

Now if it is temporarily assumed that H_C^1 and H_E^1 are correct, then Q_1, Q_2 and Q_4 may be considered as functions of H_B. Then (5) may be written as $f(H_B) = 0$, of which H_B^1 may be considered an approximate solution. But, by Newton's Law, if H_B^1 is an approximate solution of the equation $f(H_B) = 0$, then a better solution is

$$H_B = H_B^1 - \frac{f(H_B^1)}{\frac{\delta f}{\delta H_B}(H_B^1)} \quad . \quad . \quad . \quad (6)$$

From (2), (3) and (4), treating H_C and H_E as constants while considering junction B:

$$\frac{\delta Q_1}{\delta H_B} = -\frac{q_1}{K_1[Q_1^n - (Q_1 - q_1 l_1)^n]}$$

$$\frac{\delta Q_2}{\delta H_B} = \frac{q_2}{K_2[Q_2^n - (Q_2 - q_2 l_2)^n]}$$

$$\frac{\delta Q_4}{\delta H_B} = -\frac{1}{nK_4 l_4 Q_4^{n-1}} = -\frac{Q_4}{nh_4}.$$

From (5)

$$f(H_B) = Q_1 - q_1 l_1 + Q_4 - Q_2$$

$$\frac{\delta f(H_B)}{\delta H_B} = \frac{\delta Q_1}{\delta H_B} + \frac{\delta Q_4}{\delta H_B} - \frac{\delta Q_2}{\delta H_B}$$

$$= -\frac{q_1}{K_1[Q_1^n - (Q_1 - q_1 l_1)^n]} - \frac{Q_4}{nh_4} - \frac{q_2}{K_2[Q_2^n - (Q_2 - q_2 l_2)^n]} \quad . \quad . \quad . \quad . \quad (7)$$

It will be observed that (7) is entirely negative. Since $f(H_B^1) = \Sigma Q$, all the quantities in (6) can now be calculated, giving an adjusted value of H_B^1.

The junction C is next treated in the same manner, using the trial values H_C^1 and H_B^1, but the adjusted value of H_B^1 and, hence, an adjusted value of H_C^1 is obtained. Similar treatment of junction E gives an adjusted value of H_E^1.

The joints B, C and E are now dealt with a second time, and in the same order; the process is repeated a third time, and as often as necessary until the flows balance to the required degree of accuracy.

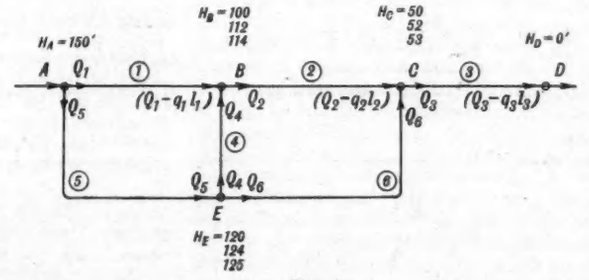


FIG. 3

Case of $n = 2$

Take as an example the same pipe network as in Fig. 1, and assume $K^1 = 1{\cdot}63 \times 10^{-8}$, $m = 5$ and $n = 2$. If the lengths and diameter

* *Journal* of the I.C.E., December, 1939, page 147. "The Analysis of Flow in Networks of Pipes," by R. J. Cornish.

† *Journal* of the I.C.E., October, 1940, page 499. Discussion on previous reference.

TABLE I

1	2		3	4	I			II			III	
	Pipe		Length, ft	d, ft	h, ft	Q, g.p.m.	$\frac{\delta Q}{\delta H}$	h, ft	Q, g.p.m.	$\frac{\delta Q}{\delta H}$	h, ft	Q, g.p.m.
		No.										
B	AB	1	4,000	¾	50	337	3·18	39	300	3·84	39·0	300
	BC	2	5,000	¾	50	334	2·84	61	364	2·57	61·0	364
	EB	4	2,000	½	20	138	3·45	11	102	4·65	11·5	105
						+101	9·47		−2	11·06		+1
							[+10·65]			[−0·18]		
C	BC	2	5,000	¾	61	364	2·57	61	364	2·57	61·0	364
	CD	3	3,000	¾	50	396	3·67	50	396	3·67	50·0	396
	EC	6	8,000	½	70	129	0·92	72	131	0·91	72·5	131
						−3	7·16		−1	7·15		−1
							[−0·42]			[−0·14]		
E	AE	5	4,000	¾	30	246	4·10	28	238	4·25	27·5	235
	EB	4	2,000	½	9	93	5·16	11	102	4·62	11·5	105
	EC	6	8,000	½	70	129	0·92	72	131	0·91	72·5	131
						+24	10·18		+5	9·78		−1
							[+2·36]			[+0·51]		

of the pipes are as in Table I, columns Nos. 1-4, then

$$K_1=K_2=K_3=K_5=12·4\times10^{-3}$$
$$K_4=K_6=52·2\times10^{-3}.$$

Taking $q_1=0·01$ (i.e., 1 gallon per minute per 100 lineal feet of pipe) and $q_2=q_3=0·02$ similarly, then

$$q_1l_1=40,\ q_2l_2=100,\ q_3l_3=60,\ \text{all in g.p.m.}$$

If the given conditions are that $H_A=150$ft and $H_D=0$, an examination of Fig. 1 suggests that reasonable trial values for H_B, H_C and H_E are 100ft, 50ft and 120ft respectively.

Considering equation (2),

$$h_1=\frac{K_1}{3q_1}[Q_1^3-(Q_1-q_1l_1)^3]$$
$$=\frac{K_1l_1}{3}[3Q_1^2-3Q_1q_1l_1+q_1^2l_1^2]$$
$$\therefore\ Q_1=\frac{q_1l_1}{2}+\sqrt{\frac{h_1}{K_1l_1}-\frac{q_1^2l_1^2}{12}}\quad\ldots\quad(8)$$

Also

$$\frac{\delta h}{\delta Q}=K_1l_1(2Q_1-q_1l_1)$$
$$\therefore\ \frac{\delta Q}{\delta h}=\frac{1}{K_1l_1(2Q_1-q_1l_1)}\quad\ldots\quad(9)$$

Considering junction B, the trial values of h_1, h_2 and h_4 are 50ft, 50ft and 20ft respectively, which are inserted in column 5. Applying equation (8) to all these pipes,

$$Q_1=20+\sqrt{\frac{h_1}{K_1l_1}-133}=20+317=337$$
$$Q_2=50+\sqrt{\frac{h_2}{K_2l_2}-833}=50+284=334$$
$$Q_4=\sqrt{\frac{h_4}{K_4l_4}}=138.$$

These are inserted in column 6; then

$$f(H_B)=Q_1-40+Q_4-Q_2=+101\ \text{g.p.m.}$$

Applying equation (9)

$$\frac{\delta Q_1}{\delta H_B}=-\frac{1}{K_1l_1\times634}=-3·18$$
$$\frac{\delta Q_2}{\delta H_B}=\frac{1}{K_2l_2\times568}=2·84$$
$$\frac{\delta Q_4}{\delta H_B}=-\frac{Q_4}{nh_4}=-3·45.$$

These are inserted in column 7, giving $\frac{\delta f(H_B)}{\delta H_B}=-9·47$, remembering that (7) is entirely negative.

Then adjusted $H_B=100-\frac{101}{-9·47}=100+10·65$, say, 111, which is entered on Fig. 1.

For joint C

$$Q_2=50+\sqrt{\frac{h_2}{K_2l_2}-833}=364$$
$$Q_3=30+\sqrt{\frac{h_3}{K_3l_3}-300}=396$$
$$Q_6=\sqrt{\frac{h_6}{K_6l_6}}=129.$$

Hence, $f(H_C)=-3$, and by a process similar to that adopted for joint B, $\frac{\delta f(H_C)}{\delta H_C}$ is found to be $-7·16$, whence adjusted $H_C=50-\frac{-3}{-7·16}=50-0·42$.

As this adjustment is less than half a foot H_C is left as 50ft and entered accordingly, in Fig. 1.

At junction E three plain pipes meet, hence the calculations are easy and the adjusted value of H_E is found to be 122ft to the nearest foot.

Now, repeating the process with the adjusted values of H_B, H_C and H_E as shown under II, Table I, the amounts by which the flows fail to balance at B and C are 2 and 1 g.p.m. respectively. At E the lack of balance is 5 g.p.m., but operation III shows that this can be reduced to −1, also improving the position at B, by taking H_E as 122·5ft.

CASE OF $n=1·85$

Experiment shows that n is not exactly 2, and hence the case of n having a different value, say, 1·85, will now be considered.

Equation (1) now becomes

$${}_A h_B=\frac{K}{q(n+1)}[Q_A^{2·85}-(Q_A-ql)^{2·85}].$$

Given a trial value of ${}_A h_B$, the solution of this equation to find Q_A will usually be obtained by a method of trial and error; but a more precise method can be devised which involves the use of the curve of $Q^{2·85}$ plotted against Q. However, it will be observed that in the example now under consideration the quantities ql are small compared with Q, and so long as this is the case an approximate method‡ can be used which yields results accurate enough for all practical purposes, using the curve $Q^{1·85}/Q$.

Thus, equation (1) may be written in the form $\frac{qh}{K}=\int_B^A Q^n dQ=S$ (previously defined).

Now, S is a strip of width ql, and since this is small, the portion of the curve Q^n intercepted by the ordinates at Q_A and Q_B may be considered straight. Then $S=qlQ_a^n$ approximately

$$\therefore\ Q_a^n=\frac{S}{ql}=\frac{h}{Kl}.$$

The quantity $\frac{h}{Kl}$ can be calculated, then inspection of the curve Q_a^n-Q gives Q_a.

Then

$$Q_A=Q_a+q\frac{l}{2}$$
$$Q_B=Q_a-q\frac{l}{2}.$$

Use is made of the same example as before and the same trial values of H_B, H_C and H_E

‡ Due to J. W. H. King.

TABLE II

1	2		3	4	I						II						III		
	Pipe		Length, ft	d, ft	h, ft	$\frac{h}{Kl}$	Q, g.p.m.	$Q^n-(Q-ql)^n$	$\frac{Q}{nh}$	$\frac{\delta Q}{\delta H}$	h, ft	$\frac{h}{Kl}$	Q, g.p.m.	$Q^n-(Q-ql)^n$	$\frac{Q}{nh}$	$\frac{\delta Q}{\delta H}$	h	$\frac{h}{Kl}$	Q
		No.																	
B	AB	1	4,000	¾	50	101,000	526	14,000	—	5·77	38	76,500	455	13,000		6·20	36	72,500	443
	BC	2	5,000	¾	50	80,700	498	33,000	—	4·88	60	96,800	545	36,000		4·48	61	98,400	550
	EB	4	2,000	½	20	19,200	207	—	5·6	5·60	12	11,500	160	—	7·20	7·20	11	10,500	150
							+195			16·25			+30			17·88			+3
										[+12]						[+1·68]			
C	BC	2	5,000	¾	62	100,000	554	36,000	—	4·47	62	100,000	554	36,000		4·47	61	98,400	550
	CD	3	3,000	¾	50	134,400	622	25,000	—	6·45	52	139,600	635	25,000		6·46	53	142,000	643
	EC	6	8,000	½	70	16,750	192	—	1·48	1·48	72	17,300	197	—	1·48	1·48	72	17,300	197
							+24			12·40			+16			12·41			+4
										[+1·94]						[+1·29]			
E	AE	5	4,000	¾	30	60,500	382	—	6·88	6·88	26	52,500	356	—	7·40	7·40	25	50,500	350
	EB	4	2,000	½	8	7,570	126	—	8·50	8·50	10	9,450	140	—	7·57	7·57	11	10,500	150
	EC	6	8,000	½	68	16,300	190	—	1·51	1·51	71	17,000	194	—	1·48	1·48	72	17,300	197
							+66			16·89			+22			16·45			+3
										[+3·9]						[+1·34]			

are assumed, reference being made to Table II, and Fig. 3. Fig. 4 is the curve of $Q^{1.85}/Q$.

Considering joint B, for pipe No. 1, $\frac{h}{Kl}=101{,}000$, whence from Fig. 4, $Q_a=506$.

Hence $Q_1=506+\frac{40}{2}=526$ g.p.m. Similarly, for pipe No. 2, $\frac{h}{Kl}=80{,}700$, whence $Q_a=448$ and $Q_2=448+\frac{100}{2}=498$ g.p.m.

The quantities $\frac{h}{Kl}$ are inserted in column 6, and the quantities Q in column 7.

For pipe No. 4, $Q_4^{n}=\frac{h}{Kl}$, which is the simple case, and is read straight off the curve. As

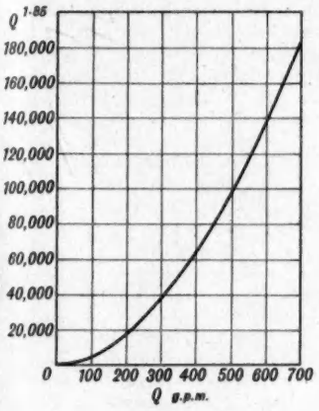


FIG. 4

the same quantity $\frac{h}{Kl}$ is required, it can be entered under column 6 as with the other pipes, but it should be remembered that the procedure is slightly different.

Thus $Q_4^{1.85}=19{,}200$, whence $Q_4=207$. Then $f(H_B)=526-40+207-498=+195$.

Reverting to (7) it will be seen that the quantities $Q^n-(Q-ql)^n$ for pipes Nos. 1 and 2 are required, and it is convenient to have an additional column—No. 8—for these, which can be read off the curve in Fig. 4. For pipe No. 4, the quantity $\frac{Q}{nh}$ is required, which can be inserted in a subdivision of column 8 if desired. The quantities $\frac{\delta Q}{\delta H}$ are now calculated, and inserted in column 9, whence $\frac{\delta f(H_B)}{\delta H_B}=-16{\cdot}25$. Hence, the adjusted value of $H_B=100-\frac{195}{-16{\cdot}25}=112$, which is entered on Fig. 3.

Proceeding to joint C, and using $H_C=50$, $H_E=120$ and $H_B=112$, the same procedure yields $f(H_C)=+24$, $\frac{\delta f(H_C)}{\delta H_C}=-12{\cdot}4$, therefore the adjusted value of $H_C=50-\frac{24}{-124}=51{\cdot}94$ $=52$ (say).

Now dealing with joint E, where the three plain pipes meet, the adjusted value of H_E is found to be 124ft.

The adjusted values of H_B, H_C and H_E are now used in the repetition of the whole process, the results being inserted under II, Table II. On carrying out the process for a third time, as shown under III, Table II, the flows at B, C and E are found to be out of balance by 3, 4 and 3 gallons per minute respectively, which are only small percentage errors.

Thus it will be seen that the above problems, which involve awkward mathematical equations, can be solved by a method of trial and error in which the errors are systematically reduced to negligible proportions.

The British Association

No. III—(*Continued from page 234, August 24th*)

THE British Association's Division for Social and International Relations in Science arranged an open meeting in Edinburgh on Monday evening, August 13th, on the subject of "World Communications: The Impact of Speed." Prominent speakers described modern scientific and technical developments in world communications by radio and aviation, and the social consequences of these developments. Dr. Edward Warner, Director-General of the International Civil Aviation Organisation, reviewed the personal and political consequences of air travel, and Dr. N. B. Cacciapuoti, of Unesco, discussed international understanding through the intellectual fellowship which links men of culture, scientists and educators.

Scientific and Technical Progress of Radio

Sir Edward Appleton, Principal of Edinburgh University, speaking on the scientific and technical progress of radio, discussed first long-distance radio transmission. The bands of radio wavelengths which were imprisoned between the earth and the ionosphere and which, therefore, travelled great distances—the so-called short waves—were used for world-wide radio services, including oversea broadcasting. In this way it could be said that anyone who was on the telephone in the Commonwealth, or other countries, notably the U.S.A., could be linked up with any other subscriber in the same network. There was, however, terrfic competition between the nations for these short-wave bands, and although a wavelength allocation plan had been internationally agreed some years ago in Cairo, a revision of it was badly needed. Many stations, Sir Edward said, were now operating outside the bands allotted to them in the Cairo plan. This applied especially to the powerful stations taking part in the cold war.

For local transmission within a given country, e.g., for broadcasting, medium wavelengths had been, and still were, much used. Here the reflective properties of the ionosphere were more of a nuisance than a bonus, for they brought about extra range at night, and there was then interference between the stations of neighbouring countries. That was why there was now a drive towards the use of very short wavelengths—shorter than the wavelengths used in oversea broadcasting. These very short wavelengths were not reflected by the ionosphere. They were escaping wavelengths, but they could be used for the broadcasting of speech, or for television, as they travelled out to escape. Their terrestrial range was, of course, short, somewhat greater than the horizon distance as seen from the lofty aerial at the transmitter. Sir Edward thought that there were important advantages in these restricted ranges when countries had to live near one another. It was like being able to live in a house without hearing the different radio programme of your neighbour next door. However, proposals had been made for increasing the range of these very short wavelengths. A programme could, for example, be sent up to an aeroplane flying in a closed circuit in the stratosphere and re-radiated from a great height to a greater service area on the earth, or the signals could be shot out to the moon and then reflected to other parts of the earth. But what was clear was that, so great was the congestion in the longer wavelength bands, one must look to the very short wavelengths for the main expansion of national radio services in the future.

Dealing with the basic theory of communication, Sir Edward said that the radio engineer, in getting information over a radio link, was always concerned with two things. First, the message itself, which might be a simple code word, or—more complicated still—a programme of music or speech, or—still more complicated—a television moving picture. The message, however, had to be discernible in the presence of radio noise which was always present in the receiving installation. Some of this radio noise was inherent in the receiver itself, some of it came from distant lightning, and so on, while some—for which, by the way, there was no excuse—was man-made, coming from neighbouring high-frequency equipment which ought to be silenced. Radio noise could be looked on as a random assemblage of signals, while the message to be conveyed involved some form of order. The easiest message to transmit was one in which the unexpectedness of it was least. At the other end of the scale, broadcasting for propaganda and information services was particularly wasteful of radio channel space. A large area had often to be floodlit with strong radio signals, loud enough for even inferior receivers to reproduce them. If peace ever did break out, he was sure that the radio engineers of the world, acting in co-operation instead of in rivalry, could guarantee to get the same information to the same people in a far more radio-efficient manner.

Yet, Sir Edward suggested, this congestion of radio circuits had set radio engineers thinking. When there was a positive and constructive collaboration between sender and receiver, it appeared that more signals than were needed were sent in order to get a piece of information over. As an example of this, he mentioned that a message which was mutilated in part by atmospherics could often be read. So more information had really been sent than was needed. It had been estimated that, when writing or speaking in English, about half the letters or words used were of people's own choice, while the remaining half were really controlled by the statistical structure of the language. The English language had, then, a redundancy of 50 per cent. This mathematical theory of communication was really very complicated, but the fact that such matters were being studied so intensively did illustrate the present-day urge towards greater economy in the use of radio channels.

Scientific and Technical Developments in Aviation

Sir Ben Lockspeiser, Secretary of the Department of Scientific and Industrial Research, then dealt with aviation developments and, after describing some of the earlier aircraft, said that none of them could pass muster to-day. Structurally, they looked like big box kites—flying contraptions

in which the pilot sat out in the open. The aero-dynamicist, the structural engineer and the aero-engine designer had just begun to roll up their sleeves; in the space of a dozen years or so, short work had been made of all the struts and wires, the cockpit had been enclosed, engines had been built into the structure, the undercarriages had been retracted, and there had emerged the prototype of the modern streamlined monoplane, of which the "Spitfire" had been a typical example. The main objects of this design had been to reduce the weight and drag—the name given to air resistance in flight. In an aircraft in steady level flight, the lift must be equal to the weight and the thrust to the drag. The lift came mainly from the air flow round the wings, which were so shaped that their lift was many times their drag. The thrust came, of course, from the propeller or a jet of combustion gases. Both the lift and the drag varied with the density of the air in which the aeroplane was flying, with the surface area and, at speeds below that of sound, with the scale of the velocity. The faster the travel, the greater the drag to be overcome, but the more the lift. The useful weight or payload was the margin of lift over and above the weight of the aircraft, its engine and fuel. To travel fast, there must not only be the necessary engine power, but it must be made worth while in terms of a reasonable payload and range. The aeronautical engineer had therefore been vitally interested in reducing the structural weight of the aircraft and in reducing the engine per horsepower and its fuel consumption per horsepower.

This paring down of weight, Sir Ben pointed out, had come partly from the metallurgist, who had given light alloys of high strength in proportion to their weight; for example, the yield point of aluminium alloys had increased from 5 tons per square inch to 35 tons per square inch for substantially the same weight in a matter of forty years. Another great contributor had been the structural engineer, who had given wings of sufficient strength and stiffness to support the whole weight of the aeroplane in flight without external struts and bracing wires. The aero-engine makers, on their part, had made an outstanding contribution in reducing the weight per horsepower of their engines from the Wright Brothers' 15 lb per horsepower, itself a remarkable achievement at the time, to just over 1 lb per horsepower to-day. Fast air travel demanded engines not only of low weight per horsepower, but units of very large power, and the lower the aircraft drag the more speed could be got out of it. Engine power and drag went hand in hand. Aircraft drag was made up of skin friction, form drag (due to turbulence set up in the airflow), and induced drag (due to the vortex flow from which the aerofoils derived their lift). Not much could be done about the last of these, but the first two were susceptible to the production engineer's skill in producing smooth surfaces and the designer's art in tucking away all structural elements which interfered with the smooth flow of air past the body.

As a consequence of these advances, aircraft speeds had increased steadily with the years and at an increasing rate. They would, however, have come to a halt about 1945 had it not been for the invention by Whittle of the jet engine. They had approached near enough to the speed of sound to find themselves in serious difficulties, because of a very rapid rise in drag due to the formation of what were called shock waves. Those shock waves first made their appearance at the propeller tips, producing a catastrophic decline in the efficiency of the propulsion.

It was at this point that the jet engine had stepped in to retrieve a seemingly hopeless situation, not only by providing engines of very high thrusts, but perhaps more important by providing a new means of propulsion by a jet of high velocity gas whose propulsive efficiency increased with speed. That was the point that Whittle had grasped, and it was safe to say that if they had had to rely on propellers for aircraft propulsion, they would not have been able to travel much beyond 550 m.p.h. Concurrently with the introduction of the jet engine had come a new advance in aerodynamic design from Germany to delay the onset of shock waves and the consequent rise in drag. This had been the swept-back wing which, if swept back by 50 deg., raised the critical speed at which shock waves were encountered by as much as 25 per cent and showed a factor of advantage of rather more than 2 over the square-set wing in the matter of drag. Further aerodynamic advantages were to be obtained by using thin wings. These were the reasons why the modern aeroplane was a streamlined monoplane with wing, tail and fin surfaces well swept back, slim body, thin wings, and powered by a jet engine. The outstanding example in transport aircraft of this design to-day was the de Havilland "Comet." The "Comet," which would come into regular operation in 1952, would fly at 35,000ft where the air density and, therefore, the drag, was only one-third of that at sea level. It would cruise at more than 450 m.p.h. and cut down the non-stop flight from London to Cairo from 9¾ hours to 5¾ hours. It would bring Johannesburg within eighteen hours from London. Sydney, Australia, would be only forty hours away.

Section G—Engineering

The final session of Section G was on Tuesday morning, August 14th, when, following the custom of recent annual meetings of the British Association, papers by young engineers were presented for discussion. They included "The Measurement of Microwave Power by Radiation Pressure," by Dr. A. L. Cullen; "Some Features of the Behaviour of Thin-Walled Structural Members in Compression," by Dr. A. H. Chilver; "A Theory of Imperfection for the Vibrations of Elastic Bodies of Revolution," by Dr. S. A. Tobias; "Cantilever Sheet Piling in Cohesionless Soil," by Dr. W. P. Rowe; "A Note on the Construction of a Model of Aberdeen Harbour," by Mr. J. D. Lawson, and "Heat-Treated Concrete," by Mr. Peter Clarkson.

Metals and Alloys

At a joint session of the Chemistry and Engineering Sections on Tuesday, August 14th, recent developments resulting from studies of metals and alloys were described. Sir Andrew McCance, F.R.S., presided, and in his introductory remarks, said that he understood that the meeting was the first in the history of the British Association to be devoted wholly to subjects of metallurgical interest. The study of metals was not only an important industrial activity, but it was a study which offered, by the multitude of its still unsolved problems, more mental stimulation than the most unreasonable scientist had any right to expect. Long past were the days when Agricola could record that "Many persons hold the opinion that the metal industry is fortuitous and the occupation is one of sordid toil, and altogether a business requiring not so much skill as labour." To-day, in spite of their chemical simplicity as elements, metals in their behaviour and properties presented problems which, by their complexity, were testing the highest skills.

While, as he had said, this was the first session of the British Association to be devoted to metallurgical matters, it was by no means the first meeting of the British Association to receive an announcement of metallurgical discoveries. One famous occasion came to mind—the Cheltenham meeting in 1856, when Henry Bessemer announced his revolutionary process for making steel from pig iron without fuel by blowing air through it. When one read the details as recorded in his autobiography of how he came to read his paper at that meeting, one was impressed by the elasticity of the arrangements permissible in those happy times. The suggestion had been first made to Bessemer a week before the meeting, although he was told that at that late date it was to be expected that his paper would be at the bottom of the list. At the meeting, however, it had been the first paper read. The audience had been expectant, for rumours had got round that there would be good fun—one of those cranks from London was going to tell them that malleable iron could be made without fuel; obviously a man with a sense of humour! To their credit, Bessemer's audience that morning had seen their mistake and had risen to the stature of that great occasion, and in many works to-day throughout the world the echo of that event was still heard during the casting of millions of tons of liquid steel made each year by the process first described in that historic paper. If the last half the of last century had been devoted to developing the art of manufacture on an ever-increasing scale, the first half of this century had been occupied with an equally intense endeavour to understand the scientific principles of the processes in use.

There was now a tolerably clear picture of the nature of liquid metals containing impurities and of the slags which covered them. On the nature of their chemical interaction, progress was also being made, the limits of knowledge in this case belonging rather to the general ignorance of kinetic processes than to the particular difficulties of their metallurgical character. In the first approach to these problems, they had been regarded of necessity as problems in chemical statics. The enunciation of the phase rule by Willard Gibbs had taken a long time to be absorbed into active scientific circulation, largely due to the difficult manner of its presentation, and many years had been spent in bringing existing knowledge of solids, liquids and solutions into a systematic scheme in accordance with its restraints. In the application of physical chemistry to metallurgical processes, Sir Andrew continued, the static view was again dominant, for all the first attempts had been concerned with equilibrium values. At the high temperatures involved, rates of reaction were also high, and it was comforting to find that equilibrium conditions were often closely approximated. With the accumulation of accurate experimental facts, however, divergencies made themselves more evident.

The remarks to be made by Professor Cottrell on the strength of metals would be a very timely contribution. Physicists had always been troubled why metals were so much less strong than they ought to be from their atomic build. The reason first suggested by Taylor, that the crystal lattice contained numerous imperfections caused by gaps in the orderly arrangement of their atoms had received widespread recognition, particularly after the ingenious bubble replica of atoms devised by Bragg had

shown that they were indeed a reality. In working out the detailed consequences of these dislocations, Professor Cottrell had been one of the foremost investigators, and he would give a review of recent developments in this field. The strengths of metals at ordinary temperatures were obviously related to their strengths at higher temperatures, and the importance of knowing how these could be improved had become a subject of major importance in recent years. The future development of the gas turbine and of jet propulsion was being hampered by inability to produce alloys of the strength required at the working temperatures demanded by designers.

The properties of the rarer metals with high melting points and their alloys were now being actively explored. Without some scientific guidance that would confine attention only to fields of composition where promising results could be expected, exploratory work of this kind would be expensive and slow. The study of alloys to bring to light the proper science of their admixture for a given result was therefore one of almost urgent importance. It had long been known that a substance like sealing wax, when slightly heated, could be bent readily without breaking, but if the same thing were tried when it was cold, it snapped at once into two pieces. At intermediate temperatures, again it would bend under gentle force, but it would break if the same force were applied quickly. It was disconcerting to find similar characteristics appearing in steel. Yet the development of welding in shipbuilding during recent years had shown that steel presenting every appearance of toughness and ductility could break unexpectedly in the most brittle manner under certain conditions. Those conditions were determined by temperature and by the character and distribution of the stresses. Much research work had been carried out in this matter and new facts had been discovered. Metallurgical art in this case had gone ahead of metallurgical science, since the problems of supplying material that made the practical danger negligible had been quickly solved, even if a complete understanding of the causes of this type of brittleness were not yet known.

The choice of subjects for the meeting, Sir Andrew remarked, had been admirably selected to bring forward some of the scientific questions which were receiving the active attention of all metallurgists at the present time.

Following Sir Andrew's introduction, papers were presented by Dr. F. D. Richardson on "The Chemistry of Metal Extraction," by Professor A. H. Cottrell on "The Strength of Metals," by Professor A. G. Quarrell on "Recent Metals and Alloys," and by Mr. T. S. Robertson on "Brittle Fracture of Mild Steel."

In the course of his paper, Professor Quarrell said that whereas engineers at first based their designs upon known alloys, they now told the metallurgist what combination of properties was required to permit optimum, or at least efficient, performance of a given machine. The metallurgist was by now quite familar with the technique and knew only too well that as soon as he had provided what he was asked for, more exacting demands would be made. Much of the metallurgical activity of this country was, in one way or another, concerned with meeting such demands. For most of the 5000 or 6000 years that metals had been used by man, metallurgy had been an art rather than a science and new alloys had resulted from chance observation rather than from deliberate effort. The last few years had seen vast strides in our understanding of the theory of alloys, but unfortunately the alloys which were most important technically were extremely complex and industrial practice still outstripped theoretical understanding. As a result, alloy development was still largely empirical and the rapidity with which existing alloys were improved and new alloys developed was due mainly to the magnitude of the effort being made and to the skill of the metallurgist in exploiting to the full any beneficial effects he observed as a result of changes in composition or in heat-treatment.

The needs of the aircraft industry for alloys of high strength-to-weight ratio suitable for airframes and for alloys capable of withstanding high stresses at elevated temperatures in aero-engines had provided the incentive for the steady improvement of light alloys and of the special alloy steels. High-strength aluminium alloys of the aluminium-zinc-magnesium-copper type were the most recent in the line of descent from Wilm's duralumin and formed a large part of most modern aircraft. Greatly improved properties, coupled with the low density of magnesium, had become available in the last few years with the introduction of the magnesium - zirconium - zinc alloys; the zirconium exerted a powerful grain-refining effect, reduced the microporosity which was such an unde irable feature of earlier alloys, and facilitated both hot and cold working. Alloys suitable for use at elevated temperatures, as in the gas turbine, had been the subject of much discussion recently and on the whole the tale was one of steady improvement of known alloys rather than of the discovery of alloys of quite new types. Austenitic steels, particularly an alloy containing nickel, chromium, cobalt, tungsten, molybdenum and columbium, had given successful service as gas turbine discs under conditions of high stress and high temperature. Ferritic steels had been continuously improved and there were now alloys with creep and scaling resistance almost approaching those of the austenitic steels and much more economic because of their lower alloy contents. Alloys based on the 80/20 nickel-chromium alloy with the addition of titanium and aluminium had proved most successful for use as gas-turbine rotor blading and continuous research by a large team had enabled the maximum working stress and temperature of such alloys to be raised repeatedly.

Professor Quarrell concluded his paper by referring to the present shortage of metals. It was clear, he said, that the metal shortage from which we were suffering was not a short-term problem resulting from the rearmament programme only. Metals were being used to an ever-increasing extent in civilian life over the world, and, moreover, some of the most important ore deposits were becoming worked out. As a result, the demand was likely to exceed the supply even of such common metals as copper, zinc and lead, and everything that could be done must be done to ensure that metals were used to the best advantage. The development of improved alloys offered one method of economising, and the progress that had been made in the last ten or fifteen years suggested that still further advances were possible. The outstanding feature of the technically important alloys was their complexity, since they often consisted of six to ten different elements, and it might well be asked whether all these were really necessary. In the present state of knowledge they undoubtedly were, but as understanding of the properties influencing the structure of alloys increased, it should be possible to get the desired properties without using certain elements. The situation might be changed considerably if those who were working on the chemistry of extraction processes were able to devise suitable methods for cheap and large-scale extraction of metals such as zirconium and titanium, which had not so far been used commercially and which had attractive properties for many every-day needs.

An abstract of Mr. Robertson's paper "Brittle Fracture of Mild Steel," is printed on page 278 of this issue.

Discussion

In the discussion which followed, Professor J. A. Pope said that the papers by Professor Quarrell and Mr. Robertson were two of the most interesting he had heard for some time dealing with metallurgy as it affected the engineer. There were one or two comments he wished to make to emphasise the engineer's approach to the problem, as distinct from that of the metallurgist, although one hoped that the two approaches were complementary.

Professor Quarrell's survey of the light alloys and other alloys available to the engineer emphasised the desirable properties of alloys by mentioning static tests. The majority of engineering failures were fatigue failures. The nature of a fatigue failure was fundamentally different from that of a static failure. In a static failure, if there were any local stress raisers they could be alleviated by plastic deformation, but the phenomenon of fatigue failure, to take even the most ductile metal, was that the fatigue crack was produced without any plastic deformation. Therefore, from the point of view of fatigue failure, really brittle and ductile metals were very much in the same category. He had drawn attention to this because, when preparing alloys, and extruded sections in particular, the surface condition from the fatigue point of view was of paramount importance. The same thing applied in the heat-treatment of steels if they were not going to be machined after heat-treatment. In his own work with steel being held at 900 deg. Cent. for thirty seconds between the salt bath and quenching, the fatigue life had been halved. If one removed by polishing $^{1}/_{1000}$in from the surface, one was back where one had been. The answer was that there had been minute notches formed on the surface which had reduced the fatigue life. It must be remembered that the size of a notch did not count; it was its sharpness from the point of view of stress concentration that counted. The same thing applied to extruded alloys. If one took a section from an extruded alloy and machined some of the specimen with a polished surface, then in certain cases it had been found that there was a very satisfactory fatigue life at ten million reversals; but if a specimen which contained the extruded surface was taken, the fatigue life in that number of reversals had sometimes been less than one-third. The answer to this was not quite known, but there was a suspicion that it was something in the surface condition which was produced in the extruding process. Those were things which engineers would like the metallurgists to look into.

With regard to steels for gas turbines, the engineer was concerned in keeping his thermo dynamic cycle at maximum efficiency, i.e., the engineer was concerned with the temperature of the gases he could use, and to him the temperature of the blade came in secondarily, because if the gases were hot, then the blade would be hot. But the blade was always working at a lower temperature

than the gas because there was a boundary layer of stationary air, speaking approximately, round the blade. Air was a bad conductor, and there was a temperature drop between the active gases and the blade which was a direct function of the heat which could be conducted away by the blade. Therefore, although the nimonic alloys were an excellent example of metallurgical development, they had the one big drawback that they were bad conductors of heat, and an advance equal to improving the creep properties could be achieved if one could have the same creep properties plus good thermal conductivity.

The other thing which was the production engineer's bugbear was machinability. Some engineers were turning their attention to the heat transfer problem. He was thinking of using materials—not nimonic—which could be more easily machined (this was purely in the laboratory stage) and constructed so that there could be water-cooling in the blades. It would then be possible to take better advantage of the temperature drop in that stationary boundary air layer, and although the working blade temperature would be much lower perhaps than one could have with nimonic alloys, the gas temperatures might be able to be higher.

On Mr. Robertson's paper, Professor Pope said that the question of brittle fracture had exercised his mind for some time, but his approach had been less practical. It had been on the basis that metals had two strengths—a yield strength, which was when plastic deformation commenced, and a cohesive strength, when actual rupture occurred. Those two fundamental strengths of the metal were not governed by the same fundamental law. The yield strength, for simplicity, could be assumed as being affected by the maximum sheer strength. It was highly probable that the cohesive strength was affected by the principal stress. If one imagined a tri-axial stress, there would be no shear stress in the cube, whereas the principal stresses could rise to infinity. However fundamentally ductile the material was, it would fracture in a brittle manner.

The other phenomenon with regard to brittle fracture was the upper and lower yield of mild steel. For a long time this had been purely an academic piece of fun, but he was not sure that with this brittle fracture of mild steel it was not one of the most important factors. If the speed of loading of mild steel was increased both the upper and the lower yield would increase the velocity, but the upper yield at a much larger magnitude of increase than the lower—so much so that one might well increase, by rapid loading, the yield strength beyond the cohesive strength. If this were done that piece of ductile mild steel, rapidly loaded, would fail in a brittle manner. The same would apply if the temperature was lowered. There were indications that the cohesive strength was not greatly affected by temperature, whereas the yield strength was affected greatly by temperature, and, therefore, by lowering the temperature, the result might be that the yield strength would get beyond the cohesive strength. It had been pointed out in the paper that by work-hardening the metal it could be got so that it was more susceptible to a brittle fracture. When one work-hardened a metal, one was bringing the yield strength higher up and nearer to the cohesive strength. That, he would say, was the engineer's approach to brittle fracture.

55kV Electron Microscope

THE "EM 4" electron microscope which is illustrated herewith, is the youngest member of the family of electron microscopes developed over the past fifteen years by the Metropolitan-Vickers Electrical Company, Ltd. The first of the series (the "EM 1") was built by the company in 1936 to the design of Professor Martin. Towards the end of the war the "EM 2" equipment was introduced and the "EM 3," which is the current production model, was developed in 1949. The "EM 4" microscope is intended to supplement its immediate predecessors rather than to supersede them. It is specifically designed as a less costly instrument, suitable for routine examination of specimens and, to that end, its performance has been limited and its controls and adjustments have been simplified.

The instrument is being exhibited by its manufacturer at the Engineering and Marine Exhibition at Olympia.

General Description of "EM 4" Instrument

Briefly, the "EM 4" microscope is a four-lens instrument (Fig. 2) using three image-forming lenses, with a fourth lens (the condenser, L_c,) to control the intensity of the beam from the electron gun. The objective lens forms an intermediate image which is subsequently enlarged by the two stages of the projector lens and projected on to the fluorescent screen. Magnifications up to 12,000 times can be attained.

The fluorescent screen is a transmission screen with an evaporated aluminium backing film for improved luminosity, and is hinged and mechanically coupled to the camera shutter. Thus, operation of the camera shutter automatically swings the screen out of the electron beam. For the illuminating system use is made of a biased electron gun which operates on a fixed voltage of 55kV from an air-insulated high-frequency d.c. set.

The microscope tube, the high-tension d.c. set and rotary backing pump are assembled in a single unit (Fig. 1). A manually operated knob controls the vacuum system which consists of an "02" oil diffusion pump backed by an "SR 2" rotary pump. A specimen air lock is fitted which allows the microscope to be operated within ten seconds of inserting new specimens.

The specified resolving power of the type "EM 4" instrument is better than 100 A.U.

Physical Principles

The principles of the electron microscope are closely analogous to those of the optical instrument. The main differences result from the use of an electron beam instead of light, and the consequent replacement of the glass lenses by others designed to produce suitable configurations of magnetic or electric fields. The design of the instrument is largely determined by the need for a high vacuum to allow free movement of the electrons. An electron gun, similar to that used in a cathode-ray tube, produces the electron beam. The lens system (Fig. 2), as in a projection optical microscope, usually consists of a condenser lens to control the electron beam, an objective lens which is mainly responsible for the quality of the image and a projector lens which provides further magnification. The electron image is projected on to a fluorescent screen where the electron energy is partly converted to light, making the image visible to the eye; alternatively, the beam forming the electron image may be allowed to fall directly on a photographic film to make a permanent record.

It was first postulated by de Broglie that a train of waves is associated with an electron in motion, the wavelength in Angstrom Units being given by $\lambda c = \sqrt{\frac{150}{V}}$ where V is the voltage by which the electrons have been accelerated. The improved resolution of the electron microscope over the optical microscope depends on the fact that the equivalent wavelength of the electron beam, as given by the de Broglie relation, is of the order of 100,000 times shorter than that of visible light.

The resolution limit of a microscope system is ultimately set by diffraction effects, and may be defined as the least distance which can separate two minute object points which still remain separate in the final image. An arbitrary standard of the resolution limit (Δd), which closely agrees with observation, was suggested by Abbé, who gave the limit as $\Delta d = 0 \cdot 61\lambda / \sin \alpha$, where λ is the wavelength of the illuminating radiation in the object space, and α is the half-angle of the cone of illumination leaving one object point and passing through the objective lens.

For the optical microscope α may be nearly 90 deg., and λ, using ultra-violet light, 2000 A.U. Thus a limiting resolution approaching 1000 A.U. may be achieved. For electrons accelerated by 55kV the wavelength is approximately

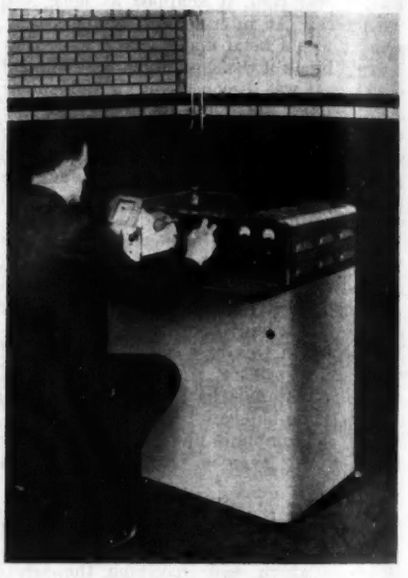


Fig. 1—"EM4" Electron Microscope

0·05 A.U., but, owing to the at present uncorrectable aberrations in electron lenses, the aperture angle (α) must be limited to 1/500 of that which can be used in the optical microscope. The theoretical resolution limit of the present electron microscope is therefore 10 A.U., which is 100 times better than that of the optical microscope, although in practice such an improvement has only been reached under laboratory conditions. Nevertheless, the resolution obtainable by the electron microscope enables detail at least twenty times finer than that produced by the best optical microscope to be viewed and recorded.

In the "EM 4" electron miscroscope, the lenses consist of axially symmetrical magnetic fields produced by iron-shrouded solenoids having pole pieces manufactured with extreme precision. (One advantage of the magnetic lens is that its focal length is continuously variable by adjustment of the excitation current: thus focusing and magnification can be varied by simple electrical controls.) To reduce chromatic aberration to a negligibly small value, it is necessary to stabilise the accelerating voltage very closely—to 0·008 per cent, or 4V in 50,000—so as to ensure that the electron beam is adequately "monochromatic." Furthermore, since the focal

length of the magnetic lens is dependent on the square of the currents flowing therein, these currents must be stabilised within twice as close limits.

Description of "EM 4" Microscope

As shown in Fig. 1, the complete instrument is mounted in a fabricated desk. The rotary pump is on anti-vibration mountings, connected by flat steel strip to the foundation of the desk. The microscope tube is sufficiently short to be mounted horizontally fore and aft of the desk with the electronic control circuits

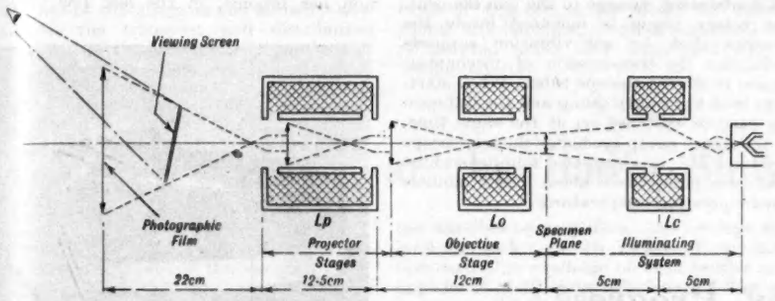


FIG. 2—RAY DIAGRAM OF LENS SYSTEM

carried on a chassis beside the tube. The high-frequency d.c. set, and rotary pump are carried underneath the desk top on a chassis at floor level; the chassis also carries the 50 c/s mains transformers for auxiliary d.c. supplies.

The electron microscope must necessarily be of demountable construction to permit the specimens under examination, and the photographic film, to be readily inserted and removed from the vacuum. In the present instance the demountable vacuum system is of all-metal construction and vacuum tightness is maintained by synthetic rubber cord seals, or, where it is necessary to transmit motion into the vacuum chamber, by rubber packed seals or flexible metal bellows. The cord seals take the form of a cord set in a square groove cut in a flange; when this flange is pulled against its plain mating flange by means of fixing screws the cord is compressed and expands sideways in the groove, thus permitting the flanges to make metal-to-metal contact. This helps to secure the high degree of rigidity of the main tube necessary to obtain the ultimate resolution of the instrument. A sectional side elevation of the main tube is shown in Fig. 3.

The use of the biased electron gun is preferred for obtaining a high intensity beam of low inherent divergence. This gun is of plate-insulator construction and is housed beneath an interlocked cover ensuring the safety of the operator. The gun consists essentially of three electrodes: a hairpin tungsten filament, a biasing shield mounted centrally in and insulated from an earthed anode. The cathode assembly is carried on the vacuum side of the plate type insulator, the supporting flange of which is spigoted into the cup-shaped anode.

A short length of three-core, low-tension cable is used to connect the cathode assembly to the high-frequency d.c. set, and is fitted with a plug and socket for easy connection.

Focusing of the electron beam on to the object space is effected magnetically by an iron-shrouded solenoid (the condenser lens *Lc*, Fig. 2), which is made integral with the anode of the electron gun. The gun condenser assembly may be tilted or traversed with respect to the specimen (for alignment of the instrument) by means of two sets of self-locking adjusting screws (Fig. 3); vacuum-tightness between the condenser and specimen stage is maintained by a flexible metallic bellows. A focusing aid is incorporated in the condenser lens.

The specimens under examination are normally mounted on a thin plastic film approximately 10^{-6}cm thick, supported on ¼in diameter 200-mesh copper grids. Three such grids may be carried on the specimen holder, which is clamped into the specimen rod by means of an eccentric screw. The specimen rod is carried in a gland type seal mounted in the mechanical stage plate outside the vacuum. Specimens are inserted into the vacuum system by pushing them, on the specimen rod, through the gland seal; the small amount of air admitted to the vacuum system is cleared in ten seconds by the vacuum pump. The mechanical stage plate is moved in a plane at right angles to the tube axis by two fine-screw threads against which it is held by tension springs. The drive to the screws is carried by flexible shafts to the front of the desk, where the control knobs are mounted.

The objective lens embodies wide-bore pole pieces, to assist accurate manufacture and allow the correct ratio (focal length/bore of lens) to be maintained. A fully adjustable objective aperture is included for increasing the contrast of the image. Magnification of the order of fifteen times is provided by the objective lens.

The projector is a multi-gap lens bolted directly to the objective lens. The lens elements are carried in a non-magnetic tube, the axis of which may be adjusted with respect to the main tube axis by means of screws. This construction enables the usual intermediate alignment section to be omitted and brings with it the advantage of having the electron beam surrounded at all its critical stages by the continuous magnetic shield of the lens shrouds. Alteration of the projector current allows a further magnification of 70 to 800 times. The overall range of magnification of the instrument is thus from 1000 to 12,000 times. Different ranges of magnification may be obtained by altering the projector lens element assembly.

The view screen is 2in by 2in and is coated with finely ground silver-activated zinc cadmium sulphide, which converts the electron image to visible light. The screen is mounted on a glass support and has its back surface aluminised to improve forward emission of visible light and also to conduct the image-forming electrons away and prevent the screen charging up. An optical magnifying lens, giving a further magnification of 2, is provided to assist in focusing the image on the screen. This screen is hinged along one edge and is mechanically connected to the camera shutter so that operation of the shutter swings the viewing screen out of the electron path.

The camera is mounted in the extreme end of the main tube and carries 5ft of 70mm film, sufficient for twenty-four exposures. There are two light-tight cassettes holding the film, so arranged that the minimum of bending takes place in transferring the film from one cassette to the other and no frictional contact is made with the emulsion-coated surface of the film. This arrangement avoids emulsion cracking and electrostatic discharges taking place in the film, even where a film has been subjected to continuous pumping for several days. The film wind is interlocked with the shutter mechanism, eliminating accidental double exposures, and a frame counter is fitted.

On account of the very small angular apertures of all the electron lenses in use in an electron microscope, the depth of focus is very great. If, therefore, the image is focused sharply on the final viewing screen, it will be in focus on the photographic film without further adjustment.

The Control Circuits

The microscope desk is made of light alloy sheet mounted on a sheet steel cabinet which is 3ft 2in high, 2ft 6in wide, and 2ft 9in deep. The instrument panel on top of the desk is fitted with hinged covers to allow access to the alignment screws, objective aperture controls, and electron gun safety cover. Access is available to the gun assembly when necessary for filament replacement.

To the rear of the instrument panel is the h.t. stabiliser, h.t. oscillator, and lens current stabilisers. All normal controls of mains supplies, lens switches, combined vacuum beam current and lens current meter, vacuum valve controls and the focuser controls are mounted on the front of the instrument panel. The light alloy desk top is carried forward to provide a writing surface, support for the operator's elbows, and storage space for "running" spares; it also carries the mechanical stage controls.

A Pirani gauge circuit is fitted for monitoring the vacuum system and a Geissler tube is fitted to assist in leak detection.

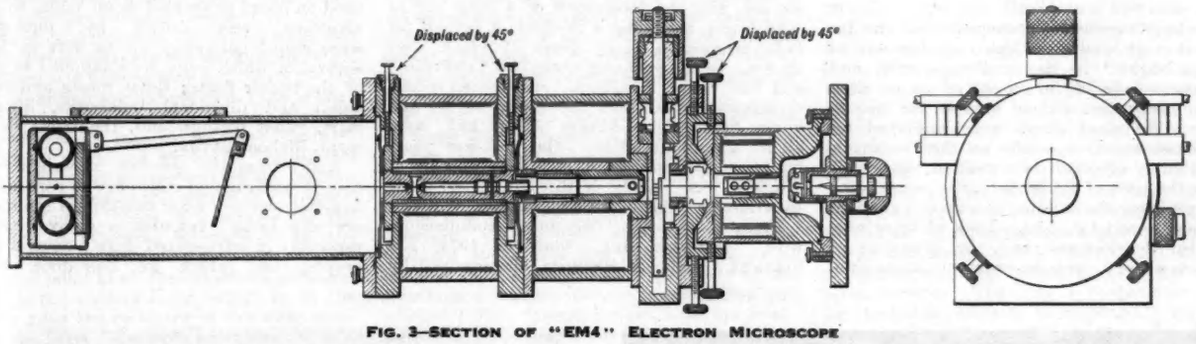


FIG. 3—SECTION OF "EM4" ELECTRON MICROSCOPE

Power Supplies

The power supply equipment, including the 55kV, d.c. set, and the lens current and main oscillator power pack, are mounted under the desk top. The high-voltage air-insulated d.c. set is fed from a high-frequency oscillator and uses high-tension metal rectifiers in a fourteen-stage circuit. The output of the d.c. set is stabilised to within 4V by a feed-back amplifier

that controls the amplitude of oscillation of the high-frequency oscillator feeding the rectifiers. A separate high-frequency transformer connected to the h.t. oscillator is used to supply the electron gun filament.

The top of the d.c. set has a screened compartment containing the gun bias and gun filament controls. Insulated rods enable them to be adjusted from the safe area outside the screening and safety covers.

The Vacuum System

The vacuum system of the "EM 4" electron microscope has been simplified and is manually controlled. A standard rotary vacuum pump is used in conjunction with an oil-diffusion pump; the latter is connected to the pumping manifold of the microscope through a high-vacuum valve. The use of this valve on the high-vacuum side allows the microscope column to be opened to the atmosphere without switching off and cooling the diffusion pump. Two vacuum valves, operated by a single control knob on the desk, are used to connect the rotary pump to the microscope for the purpose of obtaining a rough vacuum before the valve on the top of the diffusion pump is opened, after which the valves switch the rotary pump to backing the diffusion pump. The air leak for admitting air to the microscope is only accessible when the valve on top of the diffusion pump is closed. This valve is operated from the same shaft that controls the two rough-side valves; the operating knob on the shaft discloses, in the appropriate positions, push-button air leaks for letting air into the tube or air into the backing side of the rotary pump for shutting down. The vacuum valves are interlocked with the h.t. and gun filament supplies, as is also the Pirani gauge circuit, to avoid inadvertent damage to the gun filament.

The rotary pump is mounted inside the microscope desk on anti-vibration supports to minimise the transmission of mechanical vibration to the microscope tube. When starting up, both the rotary pump and the diffusion pump may be switched on at the same time, since the rotary pump evacuates the microscope to 0·01mm Hg. in about two minutes, whilst the diffusion pump needs about fifteen minutes to reach operating temperatures.

Aluminium Alloy Progress

ON the occasion of the coming of age of Birmabright, Ltd., of Birmingham, members of the technical Press were enabled to assess, by means of a comprehensive photographic display, the progress made in the application of "Birmabright," the aluminium which is manufactured by Birmabright, Ltd., for marine purposes. The guests were welcomed by Mr. E. Player, the managing director of Birmid Industries, Ltd., who briefly reviewed the history of the development of the company's aluminium alloys from the tentative beginnings to the present scope as exemplified in the accompanying photographs. Early difficulties were lightly touched upon and the alloys, he stated, were engineering materials which had achieved their present status upon their merits and the suitability of physical properties to meet a wide range of specifications.

Exhibition of Photographs

The large number of photographs set out for inspection showed individual applications of "Birmabright" to items of equipment and construction already in service in one or other of the many and diverse uses in the marine field. Aluminium alloys were employed for the construction, especially on the Continent, of a number of small river craft in the decade before the turn of the century, the outstanding example being the building of a French gunboat by Yarrow and Co., Ltd. Lack of knowledge retarded development and the invention of the sea-water corrosion-resistant aluminium alloy "Birmabright" gave impetus to marine applications. Illustrating the corrosion-resistant properties of "Birmabright" there was displayed a sample of material cut from an old working punt which was unpainted and had spent ten years in fresh water and ten years in salt water. The material, of No. 12 gauge, 3 per cent aluminium-magnesium alloy, sheet, was in excellent condition the maximum depth of pitting being 0·008in. The mechanical particulars recently obtained from a test piece cut from the sample were: 0·1 per cent proof stress; 11·1 tons per square inch; ultimate stress 17·2 tons per square inch, and 13 per cent elongation, the corresponding values for the B.S. 1470 Standard being 11 tons per square inch, 17 tons per square inch, and 8 per cent elongation respectively.

A number of small craft were built and a motor cruiser, now named "Diana II," and still in excellent condition after twenty years' service, was the forerunner of a long line of such boats, including a firefloat, a launch for Lake Maracaibo, many views of which were shown. In the yachting world the "Gulvain" and the "Four Freedoms" represented recent construction, in which the mast, booms and minor fittings, in addition to the hull, were all of aluminium alloy. The post-war years have seen the production of a large number of dinghies. A variety of these dinghies, built by a number of firms, were illustrated.

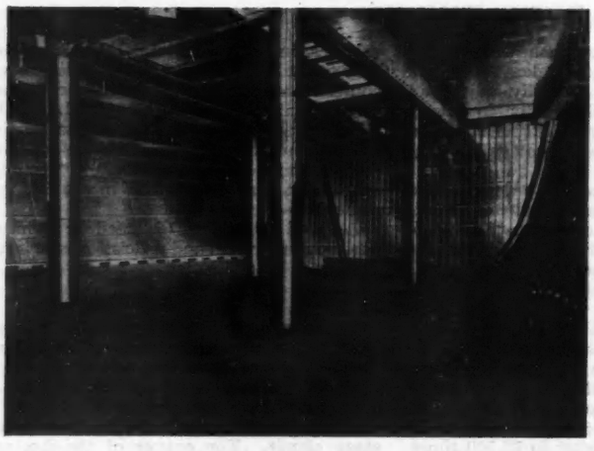
From a tentative beginning, commencing with "Barnacle Bill," built in 1934, has followed a family of lifeboats, all approved by the Ministry of Transport, and the rapidly expanding adoption of the light alloy lifeboat by the shipping companies. Photographs showed some of the notable ships equipped with "Birmabright" lifeboats, including the "Nieuw Amsterdam," "Willem Ruys," "Andes" and "Caronia."

In recent years the lightweight and non-magnetic properties of the alloys have been put to use in the building of wheelhouses for a large number of vessels and, where a ship's stability was in question or additional load-carrying capacity was required, then the deckhouses and superstructures have been erected in light metal. This form of construction has become, in the last few years, an important factor in the design of trawlers and whale catchers, and, in addition, the funnel casing has also been built in the same material. Funnels in light alloys have not been confined only to small ships, a number of passenger liners have been so equipped and a completed funnel is shown in our illustration.

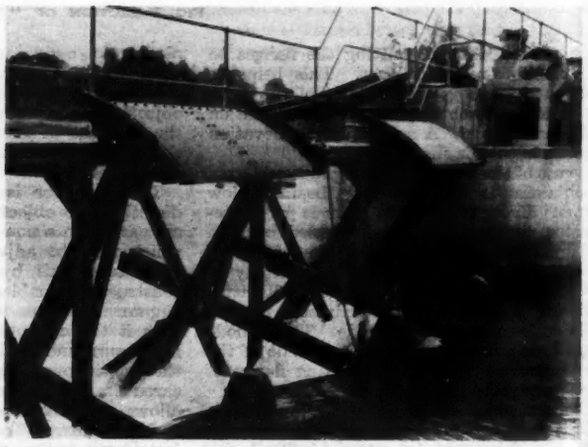
SHIP'S FUNNEL

Among the more detailed equipment items used on board ships and small craft, to which attention was drawn by photographs were ships' gangways up to 40ft in length, several of which have been supplied to vessels of the tanker fleets; radar masts and towers, cabin and divisional bulkheads, life-saving rafts, yacht fittings, and, the latest development, lifeboat davits.

Apart from the question of weight saving, ease of working and resistance to corrosion, the hygienic and non-toxic qualities of the material are now being exploited in many directions, especially in refrigerated ships. Several photographs, one which we reproduce, showed



REFRIGERATED HOLD



SLUICE GATES

"Birmabright" sheet used for lining the holds and 'tween decks of a number of vessels of the Port Line, an application which has proved successful economically and has resulted in an improvement in the arrival condition of the cargo. The aluminium alloys are gaining wider appreciation in the fishing industry, where the demand for light metal fittings has steadily increased. The economic advantages, especially with regard to landing the catch in top grade condition, has resulted in the adoption of the alloys for fishhold lining, stanchions, pound boards, shelving and divisions, and the display showed many examples of this form of equipment. In addition, the photographs showed that the use of the alloys in the industry now extends to the transport and distribution services which are employing trawler trunks, fish boxes and fish kits made in "Birmabright."

Naval use of the metal was shown in a view of the all-aluminium alloy motor torpedo-boat, "P.1602," which is fitted with aluminium alloy torpedo tubes. Another interesting application, illustrated herewith, is the employment of the alloys for the construction of sluice gates now in use at a number of locks controlled by the Thames Conservancy. The low specific gravity of the material has reduced not only the weight of the structure, but also that of the balance weights.

In association with its coming of age, Birmabright, Ltd., has issued a number of brochures which contain technical information and photographic illustrations of actual marine applications of the company's alloys for lifeboats, yachts and launches, dinghies and small craft, refrigerated ships and equipment for the fishing industry.

Technical Services at the Radio Show

THE Radio Show at Earls Court, London, W.1 (August 28th to September 8th) provides an interesting example of the complexity of the technical services that are needed for demonstrating radio and television receivers.

Seven main services have been made available as a result of arrangements made by the exhibition technical committee of Radio Industry Council. The first service is a closed-circuit r.f. television distribution system, over which suitable programmes can be relayed daily from 10 a.m. to 10 p.m. from any one of the following three sources: the normal B.B.C. television programme as radiated; films from a film scanner housed within the Radio Industry Council's technical control room; or live programmes picked up by cameras in a B.B.C television studio specially built within the exhibition.

The second service is a sound reinforcement system throughout the Show, over which suitable musical programmes and announcements are radiated. There is also a subsidiary sound reinforcement system relaying sound from within the B.B.C. studio to those looking through its glass-panelled walls. Fourth, there is a medium-wave r.f. signal, on closed circuit, of higher than average quality for the demonstration of exhibitors' radio receivers in special demonstration enclosures. Fifth, superimposed on the network carrying the medium-wave r.f. signal there is a high-quality a.f. signal for the benefit of exhibitors who may wish to show such equipment as magnetic tape recorders, amplifiers, loudspeakers, &c. Sixth, there is a technical control room and studio for the control and distribution apparatus and for the origination of programmes in the second of the above services. Finally, there is a service for the prevention of electrical interference to the services within the exhibition.

The focal point of all the exhibition technical services is the control room, which is on the first floor near the escalator in the wing overlooking the West Brompton entrance. It is a rectangular structure with glass panels on nearly the whole of three sides, while from the front of the long side projects the small glass-panelled studio in which the sound programme announcer sits controlling the sound programme material for the exhibition. While the control room is of simple shell construction and has rooms inside for stores and technical personnel, all the equipment for the technical services will be on view to the public through the glass panels and it may be watched in operation. The small studio itself is sound-proofed by a double skin and is acoustically treated inside to give the best working conditions.

The television distribution system enables any one of the three sources of programme to be selected and distributed to television receivers operating on exhibitors' stands and in the demonstration avenue. After selection, the signal is demodulated where necessary, passed through control faders and used to remodulate a small local transmitter which in turn feeds the distribution amplifiers. An average signal level of 1mV ±3 db measured on B.B.C. test card *C* is available at each output at an impedance of 70 ohms unbalanced. The same system of distribution is being employed as in previous years and the exhibition is fed by a number of coaxial trunks running from the control room to outlets on stands correctly terminated for the receivers. The far end of certain trunks are returned to the control room so that the signal at the end of a typical cable run is available for monitoring purposes. The carrier frequencies used for sound and vision on the exhibition closed circuit do not use channel 1, but those of Sutton Coldfield (channel 4) with carrier frequencies of 61·75 and 58·25 Mc/s for vision and sound. This change of frequency has been found to be essential, since it is often desirable to distribute programmes within the exhibition while another programme is being radiated at the same time from Alexandra Palace. Any r.f. pick-up on the network or on the wiring of exhibitors' receivers does not, therefore, result in beat patterns interfering with the picture. The specification for the television signal to be distributed from the equipment conforms fully to standard B.B.C. practice and some of the salient characteristics are as follows:—pass band, no worse than 2 db down at 2·5 mc/s, or 4 db down at 3 Mc/s; linearity, within 5 per cent to peak white; sound, modulation constant within 3 db over the frequency range 50 to 7500 c/s.

Further, harmonic content of the modulation envelope does not exceed 5 per cent at or below 75 per cent modulation or 10 per cent below 85 per cent modulation; and spurious modulation does not exceed 0·2 per cent.

The film scanning equipment is next to the television distribution racks and enables standard 35mm non-flam cinema films to be scanned and passed at video frequency to the distribution panels. Certain special films and selected B.B.C. television news reels are available and the equipment includes a caption scanner to enable announcements to be transmitted from still transparencies. Suitable tie-lines are provided so that special sound announcements from the announcers' studio can be used to modulate the television sound channel.

The sound reinforcement system for the main halls is effected by a large number of slot type loudspeakers operated at low level. The exhibition has been divided into sections so that the level in any one section may be varied in relation to the others to give the desired result.

Within the announcers' studio there is a special console, at which are available on music lines the two main B.B.C. programmes, while two gramophone turntables are installed so that records may be played by the announcer at will. The whole equipment is being designed to allow working similar to the normal B.B.C. continuity studio practice in which the control engineers are responsible for setting up the levels while the programme itself is directly controlled by the announcer on duty. The levels having been set by the engineers, faders and a master fader are available to the announcer. Two microphones are provided with independent controls so that guest announcers can be invited to the studio. The output from the console goes to pre-amplifiers, which in turn feed the main amplifier racks and, thence, the loudspeaker networks. The subsidiary sound reinforcement system is mounted in the same racks as the main system, but receives input direct from the B.B.C. control room next to the B.B.C. studio and the output is supplied to a number of loudspeakers operating at low level just above the glass windows surrounding it. In this way not only can the public hear the programmes being produced within, but during rehearsals the producer's instructions and other "behind the scenes" activities can be followed.

While the accent of such a radio show falls very largely on television, it must be remembered that a big percentage of the exhibits are radio sets, loudspeakers, recorders, &c., and two services are produced so that these may be adequately demonstrated. A coaxial cable network will feed a broadcast type signal on a frequency of 1030 kc/s ±150 c/s, to a number of demonstration rooms on the first floor in the Show, so that normal broadcast receivers may be operated under conditions closely simulating those in the average home. Specially selected programmes recorded on magnetic tape are used, modulating a small local transmitter in the control room to provide this signal.

A few of the salient characteristics of this signal are as follows: signal level at each outlet, 300mV; frequency characteristic, ±2 db from 20 c/s to 14 kc/s; harmonic distortion, less than 2 per cent within this range up to 90 per cent modulation. All forms of noise and hum are more than 50 db below the 90 per cent modulation level.

The second system provides for a high-quality audio frequency signal which is to be superimposed on the cables carrying the r.f. medium-wave signal and, where required, a special termination box in the demonstration room concerned can make this available to the exhibitor. The a.f. input is obtained from Post Office music lines and, in general, consists of selected B.B.C. musical programmes. The overall frequency response from input to any a.f. outlet is within ±3 db from 20 c/s to 16 kc/s. Harmonic distortion is less than 1 per cent at any frequency between 20 c/s and 3 kc/s up to an output level of 1V r.m.s. All forms of noise and hum are −50 db at an output of 1V r.m.s. In this way it is hoped to provide a signal which may be of considerable use to exhibitors wishing to demonstrate high-quality apparatus and for whom a demodulated r.f. signal may not prove satisfactory.

The last, but by no means the least, exhibition service provided is the responsibility of the committee, working through a member-firm, to ensure that no apparatus is introduced capable of causing electrical interference to the exhibition services. The firm, in conjunction with the technical officers, is responsible for the investigation of complaints of radio interference with exhibition services and for ensuring that the necessary suppression measures are taken. Experience has shown that it is necessary to exclude completely such things as commutator motors and to make suppressors for discharge lighting a *sine qua non*. As the Radio Show has moved to Earls Court, a completely new set of conditions pertains from the point of view of interference and the task of ensuring that exhibitors receive signals free from this trouble involves continuous vigilance. The technical committee has taken special measures to ensure that programmes received over the air from Alexandra Palace are unaffected by external interference. Arrangements have been made to provide a micro-wave radio link on 6800 Mc/s between Alexandra Palace and Earls Court over which the B.B.C. television programmes will be taken. As a standby a normal aerial will be provided, and by these means it is hoped to enable the public to view television under the best conditions obtainable.

Metallurgical Topics

Conservation of Alloys: An American Discussion

A "panel discussion," which took place last March before an audience at the Western Metal Congress, Oakland, California, is reported in the June number of *Metal Progress*. At the outset, reference was made to the advantages still to be gained by improved ore dressing, by "pressurised" blast-furnace operation, and by the use of oxygen-enriched air especially in ferro-alloy furnaces; but the main subject was the conservation of alloys, a matter which is going to be much more serious, especially for civilian industry, in the future than in the past. The problem of the substitution of one steel for another immediately brings up the question of what can be used as a criterion of quality. Classification by hardenability might, at first sight, appear to leave out considerations of ductility and toughness. The answer put forward was that if a steel, when quenched, showed at least 90 per cent of martensitic structure throughout the section, it would, when adequately tempered, exhibit the most desirable combination of hardness and toughness. It was no longer possible to "pick up the slack of poor heat-treating" by giving the product a richer alloy composition; hence the importance of strict control of heat-treatment conditions applied to compositions containing the minimum amount of alloy to meet service requirements.

Shallow-Hardening Steels

To obtain a 90 per cent martensitic structure throughout was a counsel of perfection, but shallow-hardening steels chosen to give a proper degree of hardenability at the surface or at about one-quarter of the distance from surface to centre gave excellent results. Millions of parts have been so hardened, and have been used very successfully. If the part is stressed in torsion or in bending, then one-quarter of the distance from the surface to the centre is all that needs to be 90 per cent martensite. When it is possible to put up with somewhat inferior properties at the centre the hardenability demanded, and thus the alloy content, of the steel may be reduced to a minimum; and incidentally risk of distortion becomes less.

Economy of Manganese

There was little reference to the use of manganese as an alloying element. In America they are faced with a possible shortage of manganese for ordinary steelmaking purposes, and the Bureau of Mines has long been attacking the problem in a number of directions, such as the use of low-grade domestic ores, the study of the minimum amount of manganese required in steels containing various amounts of sulphur, the substitution of the manganese (or part of it) by titanium for deoxidising, or even by zirconium. Such substitution is likely to be deferred as long as possible, as it would involve higher cost and complications in current practice and would have a distinct bearing on the hardenability of carbon and low-alloy steels.

Boron Steels

It is now an established fact that the hardenability of some types of steels is, in certain circumstances, materially enhanced by the addition of a small amount of boron; and inevitably the use of boron was advocated as a solution to many difficulties. Boron-treated compositions, designed to make maximum use of the alloys contained in scrap, have been announced by the Technical Committee on Alloy Steels of the American Iron and Steel Institute. One series contains nickel 0·30, molybdenum 0·12 and chromium 0·25 per cent and is designed to have a hardenability equivalent to that of steel of the same carbon content, but containing nickel 0·55, chromium 0·55 and molybdenum 0·2 per cent. Another series with nickel 0·30, molybdenum 0·12 and chromium 0·43 per cent is designed to have a hardenability equivalent to that of the 1 per cent chromium, 0·2 per cent molybdenum steel.

It was pointed out that the effectiveness of boron depends, not only on the base composition of the steels, but also on the deoxidation practice. A steel can be treated with boron without its hardenability being improved. After slack quenching or tempering at a high temperature, steels containing boron are not as good in behaviour as other steels in which quenching does not produce an all-martensite structure. Some members of the panel were enthusiastic supporters of boron treatment, saying that there might be lots of trouble, but that all such difficulties were or would be quickly overcome.

Reference was made to work carried out at the Bureau of Standards on thirty-two ingots of boron-treated steel from an open-hearth heat. The procedure was to make the boron additions with one of seven "intensifiers" in the mould at regular intervals throughout the pouring in order to have ingots of three different boron contents treated with a selected intensifier. The hardenability curves obtained from end-quench tests were similar for boron-treated specimens prepared from the ingots and for specimens prepared from bars after hot rolling to 1¼in rounds. Furthermore, regardless of the composition of the intensifier and the amount of boron retained, the hardenability was markedly improved by each boron addition. The base composition of this heat was carbon 0·43, manganese 1·6 per cent, and the average hardenability was about equivalent to that of steel containing carbon 0·45, chromium 1·0 and molybdenum 0·2 per cent when comparisons were made on the basis of 95 per cent martensite or slightly inferior on the basis of 50 per cent martensite.

Other Hardening Elements

A passing reference was made to the effect of phosphorus on hardenability, and later the use of phosphorus in low-alloy high-strength structural steels was commended as a means of conserving strategic elements. Nitrogen was also mentioned as an element which stabilised austenite and contributed to hardenability. The tendency of both these elements to lead to brittleness of one kind or another was not overlooked, but the value of nitrogen in surface hardening processes was emphasised.

Case Hardening

Carbonitriding does not require as high a temperature as carburising. Distortion is less and oil quenching is sufficient. This frequently means that a plain carbon steel carbonitrided can replace an alloy steel carburised. This contribution, indicating a way in which nitrogen can play its part, led to consideration of the properties of the core, and the discussion again returned to the subject of boron.

More About Boron Steels

It was stated that boron steels were now being offered as substitutes for the old standard carburising steels, but that the case hardenability, being in the high-carbon region, did not get the benefit of any increase due to boron. Moreover, difficulties were encountered if boron-treated steels were carburised at too high a temperature. In spite of the experience with ingots and rolled rod referred to above, it had been found at the Bureau of Standards that the action of boron could be adversely affected during the course of forging or other thermal treatment. High-purity iron-carbon-boron alloys had been examined as cast and as forged and homogenised. The cast specimen had the expected improvement in hardenability due to boron, whereas the same composition after forging and homogenising did not show the enhancement. They also found that steels deoxidised with aluminium and treated with ferro-boron often showed austenite grain coarsening at lower temperatures than similar steels without boron. Another fact of importance was that if the steel contained relatively high soluble nitrogen the boron was relatively ineffective in improving hardenability, though it was possible to retain the boron effect in high-nitrogen steels by the use of strong nitride-forming elements, such as titanium or zirconium, to fix the nitrogen and thus decrease the amount of soluble nitrogen for reacting with the boron. The nitrogen content was usually sufficiently low in steels made in the open-hearth or other commercial processes for the desired improvement to be obtained in deoxidised heats treated with ferroboron.

The Final Question

At the conclusion of the session the chairman (Mr. E. E. Thum) sought an assurance that equivalence in hardenability bands really meant ability to replace one steel by the other. He asked if it were true that steel *A*, which had a certain hardenability band, was equivalent in its use and mechanical properties to steel *B*, which had the same hardenability band, even though it might be far distant from it in chemical composition. Mr. W. E. Jominy replied that it was true as regards mechanical properties of steels within the hardness range 200 to 400 Brinell, provided that they had been hardened to give a microstructure of at least 90 per cent martensite before being tempered. He said that though British metallurgists might demur, most American metallurgists would agree with this answer. He was, however, confronted with a statement which he himself had published a few years ago, in which he gave the transition temperatures of four different steels, all hardened fully and tempered back to the same hardness. Those which contained nickel had a lower transition temperature than those which had no nickel at all. For applications in liquid oxygen production, in chemical industry and in aircraft, this seemed to be very important. Mr. Jominy then modified his reply so far as to say that in steels of the same hardenability certain specific differences might exist affecting special applications. Special compositions gave very low transition temperatures, and phosphorus might raise the transition temperature from tough to brittle fracture. In such applications as automobile construction, however, if the steels were hardened to martensite and then properly tempered (to avoid temper-brittleness, for example) differences were usually insignificant and the transition temperature lower than 40 deg. below zero.

Advances in Metallography

In 1926 the third H. M. Howe Memorial Lecture was given by Professor W. Campbell, of Columbia University, on the subject of "Twenty-Five Years of Metallography." Twenty-five years later, Mr. J. R. Vilella, the well-known metallurgist and metallographer of the research department of the United States Steel Corporation, has brought the subject up to date in the Howe Lecture for 1951, which he has entitled "Twenty-five More Years of Metallography."* He pointed out that the metallographic methods most widely used to-day (with the exception of the electron microscope) were already firmly established twenty-five years ago. Specimens are still prepared in a similar manner, improvements being in the nature of refinements and superior equipment. Mechanical metallographic polishing is still universally practised. Electrolytic polishing, though now available, is not widely used, as, except in a few special cases, its results are inferior to those of competent

* *Journal of Metals*, August, 1951, page 605.

mechanical polishing.† Most of the etching reagents preferred to-day were in common use more than twenty-five years ago. Very good achromatic and apochromatic objectives were available at that time. Present-day high-magnification, optical micrographs do not surpass those that could be produced twenty-five years ago; but, on the whole, the standard of micrographs in current metallurgical literature shows a distinct improvement. This may be attributed to better preparation and to a better conception of what constitutes a properly prepared specimen. Not long ago, many photographs still fell short of the best attainable by such defects as uneven illumination, pits resulting from the dislodgment of non-metallic inclusions, excessive or insufficient contrast, or incomplete removal of the disturbed layer. Recognition of the persistence of the disturbed layer after a single etching, and its elimination by the practice of alternate polishing and etching, have been among the factors which contributed most to a knowledge of the structure of steel and to the progress of metallography in general. Nevertheless, the interpretation of the structures, now more clearly revealed, would have been delayed had it not been for a contribution from the field of physical metallurgy—the isothermal transformation diagram.

The Electron Microscope

The first attempts to use the electron microscope for the study of precipitation phenomena in metals demonstrated its ability to resolve significant details beyond the limits of the optical instrument, but it was immediately apparent from the markedly dissimilar results obtained by different investigators that before its inherent advantages could be realised the causes leading to such diversity of results had to be ascertained and eliminated. Since then, in co-operative investigations, it has been demonstrated by comparison of structures which were also resolvable under the optical microscope, that high-fidelity electron micrographs of steel could be obtained by present-day replica techniques. This gave confidence in the ability of the method to show the true appearance of those structures that were too fine for adequate resolution by the optical microscope. Nevertheless, Mr. Vilella calls attention to a few apparent failures of the electron microscope to reveal subtle differences in structure of steel, with the object of emphasising his opinion that further refinements of technique are necessary before the full potentialities of the instrument in the field of metallurgy are recognised.

Microscopes and Accessories

The metallurgical microscope had already become standard equipment more than twenty-five years ago and further changes have been in mechanical improvements and refinements which have increased the versatility of the instrument. Examples mentioned were conical illumination, whereby only inclined rays are used to illuminate the specimen obliquely and a stereoscopic realism is given to the appearance of the surface, and the use of polarised light, which sometimes helps in the identification of non-metallic inclusions, but its value in identifying special constituents (such as the sigma phase in iron-chromium alloys) or "grains" in martensite, though sometimes claimed, has not been fully substantiated.

Phase Contrast

Another optical accessory recently made available for incorporation into the metallurgical microscope is an attachment for illuminating the specimen under conditions known as phase contrast. Two parts of the microstructure at different levels, but of the same colour and reflectivity and therefore equally bright under ordinary illumination, may be distinguished by the phase contrast system, since differences in level produce differences in the phase of the light reflected from them, and these differences are converted into differences in brightness. By this means it is possible to show differences in level of 50Å or approximately 20 interatomic distances. Mr. Vilella expressed the opinion that, although phase contrast illumination had hitherto contributed nothing of significance to our knowledge of the structure of steel, it would be premature to pass a judgment on its eventual merit.

Coated Lenses

For the elimination of "flare" (light reflected from the back of the lens), which may seriously impair the contrast of the image, objective and eyepiece are coated with a transparent film whose thickness is approximately one-quarter of the wavelength of the incident light. When the film has the correct index of refraction, the light reflected from the glass film and from the film-air interfaces interfere destructively, and only an inconsequential amount of light is then reflected from the surface. Mr. Vilella further explains how the anti-reflection coating also, in other ways, leads indirectly to photographic conditions favourable to the production of the best possible micrographs.

Interference Filters

Whilst coloured glass light filters are satisfactory for all but the most exacting metallographic work, the portion of the spectrum which they transmit is sufficiently wide to include wavelengths for which the objective was not adequately corrected. Reference was made to the transmission type of interference filter, consisting of two semi-transparent films of silver separated by one of magnesium fluoride deposited on a glass plate with a cemented cover-glass for protection. By multiple reflection between the silver films through a layer of magnesium fluoride half a wavelength thick, maximum transmission of light of a particular wavelength occurs while light of other wavelengths is blocked.

Colour Metallography

With the introduction in recent years of colour films having a high order of resolving power and comparative ease of development, there has been a rebirth of interest in colour metallography. When colour differences are significant it is of value, but in ordinary ferrous metallography where shades of grey predominate its extended use can hardly be justified.

Mr. Vilella dealt briefly with photographic materials in general, and spoke in favour of the use of films rather than glass plates. He thought that these might become available to an increasing extent for micrographic purposes as the flatness of films, inserted in well-made sheaths, was perfectly satisfactory for all magnifications.

Ultra-Violet Microscopy

An objective of numerical aperture 1·6 used with blue light of wavelength 4500Å is equal in resolving power to one of numerical aperture 1·3 used with ultra-violet light of wavelength 3650Å. Mr. Vilella considers it desirable to obtain the advantage of increased resolution by employing illuminants of short wavelength rather than objectives of high numerical aperture.

An ultra-violet light objective was designed and manufactured by the Bausch and Lomb Optical Company as long ago as 1930, so that the green mercury line with wavelength 5460Å and the ultra-violet of wavelength 3650Å were simultaneously in focus. This made it possible to focus with a green filter, substitute a filter with maximum transmission at 3650Å and make an exposure. Since the absorption of ultra-violet light of this wavelength by glass is slight, no change from glass to quartz was necessary, though sandal wood oil is preferable to cedar oil for the immersion medium because it absorbs less of this wavelength.

High resolution is also obtainable by the use of the reflecting objectives recently introduced for ultra-violet microscopy by transmitted light. These lenses are achromatic over a wide range of wavelengths, including both visible and ultra-violet regions of the spectrum, so focusing presents no difficulty. They are also made by Bausch and Lomb, but are not yet available for metallography, though Mr. Vilella gives an example of their performance in a photograph of Bainite made with a water-immersion reflecting objective of numerical aperture 1·1 and ultra-violet light of wavelength 3650Å at a magnification of 2000.

Conclusions

As will have been observed, many of the developments referred to in the lecture were of a specialised nature and, hitherto, of very limited application. In conclusion, Mr. Vilella expressed the opinion that the general progress achieved in the last twenty-five years was brought about by the following accomplishments:—

(1) Elimination of disturbed metal from the surface of specimens, which enabled us to see the true configuration of the structures of the steel.

(2) Development of the isothermal transformation diagram, which helped us to understand the structures unveiled by the elimination of the disturbed metal.

(3) Application of the electron microscope, which enabled us to see finer detail than had been seen before.

† It should be noted that the lecture dealt almost exclusively with ferrous metallography.

Intercrystalline Cracking Possibly Due to Nylon

A surprising incident reported by E. J. Silk* suggests that a Nylon gear, working in contact with an aluminium bronze clamp ring in a city water service, may have been responsible for intercrystalline cracking of the aluminium bronze. The assembly consisted of the Nylon part held to a stainless steel part by means of the clamp ring and silicon bronze screws. The clamp ring failed in a brittle manner at two diametrically opposite points. Intercrystalline cracks were found originating at the surface in contact with the Nylon. The alloy contained copper 94·5, aluminium 5·2, arsenic 0·2 per cent. Its tensile strength is given as nearly 47 tons per square inch, so it must have been fairly severely cold worked. It was said to have been ductile, but no figures were given. There was no direct evidence, but merely inference, that the Nylon was responsible. In view, however, of the increasing use of plastics in association with metals, the question raised by this failure may be of importance.

New Brazing Alloy.—The latest addition to the Colmonoy alloys, distributed by A. S. Young and Co., Ltd., Tower Works, London, N.12, is "Nicrobraz," which is a new brazing alloy belonging to the stainless group and having excellent heat and corrosion resistance properties. It has a melting point at 1850 deg. Fah., flows readily at 1900 deg. Fah. in a pure dry hydrogen atmosphere, and research has been associated with assemblies operating at 1200 deg. to 1800 deg. Fah, which range covers work for jet engines. Before brazing the alloy has a Rockwell C hardness of 60 and the new alloy formed, when brazing a stainless steel joint; has a hardness value between 30 and 35. Tests have shown that the ductility, shear strength and corrosion resistance of the "Nicrobraz" joint are almost the same as the parent metal, while the high-temperature tensile strength closely approximates the curve given for stainless steel, particularly over the temperature range 1200 deg. to 2000 deg. Fah. The oxidation resistance of a "Nicrobraz" butt joint on stainless steel was tested by comparing tensile strength at room temperature with values obtained after subjecting it to a temperature of 1500 deg. Fah. in air over periods of time extending to 500 hours. No visible signs of oxidation were noted and there was no reduction in strength. Surface grinding is recommended for joint preparation and a minimum clearance of 0·002in, the brazing being carried out at 2100 deg. Fah. in an atmosphere of pure hydrogen, dewpoint minus 40 deg. Fah., to prevent oxidation of the chromium. The alloy is a powder, it is applied outside the joint and flows in by capillary action and also has excellent wetting and alloying characteristics. "Nicrobraz" has been used successfully with carbon, alloy and tool steels, carbides, monel, and vitallium, and its corrosion resistance makes it suitable for use in the food, chemical, automotive and oil industries.

* *Journal of Metals*, August, 1951, page 600.

THE ENGINEER

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SIXTEEN-PAGE DESCRIPTIVE SUPPLEMENT—Engineering and Marine Exhibition at Olympia

OLYMPIA AGAIN

YESTERDAY there once more opened at Olympia in London an engineering exhibition that has been held regularly every two years (save only for the gaps caused by two world wars) since 1906. It has been held under a variety of titles. This year it is officially named the Engineering, Marine and Welding Exhibition. But to engineers who have grown accustomed to looking forward to the event it has become known more shortly as the "Olympia Exhibition." In appearance it is a "trade fair," at which the manufacturers of engineering products show their wares to prospective customers and hope to recompense themselves for the expenditure to which they have been put, by gathering orders. In fact, however, it has become something more. It is now a technical and social event at least as much as it is a trade occasion. Information and technical knowledge is mainly spread by the technical Press, and by the presentation and discussion of papers before Institutions. But neither articles in the Press nor papers before the Institutions can fully convey the impression of engineering in the "round." Here at Olympia, however, once every two years, engineers can meet and can talk shop surrounded by their products, and whenever some point of difficulty arises refer directly to the solid thing itself. From the first the late Mr. F. W. Bridges, who started an Exhibition whose organisation has since been ably carried on by his son, foresaw that it could be made something more than a trade fair. No doubt in exerting himself to arouse interest amongst engineers of all kinds in the Exhibition he had principally in mind a desire to attract prospective customers to the stands. But the methods adopted by him and carried on by his son, the appointment of numerous "patrons" amongst eminent engineers, the setting aside of particular days at which members of Institutions can expect to find fellow members at the Show, and so forth, were undoubtedly particularly well adapted to enhance the social and technical as much as the trade atmosphere.

Every second year, as we set about preparing, in advance, descriptions of the exhibits to be shown, we tend to become depressed; every time it seems to us that on this particular occasion there is less at the Show that is novel, less of real interest to engineers than there was the time before. Yet we suspect that the Olympia Exhibition is beginning to share with *Punch* and the rising generation the exalted reputation of never being as good as it used to be! It is, of course, possible that the impression formed this year before the doors are opened that less that has the special interest of novelty will be on view is correct. There would be no lack of excuse for it. For during the two years since the Exhibition was last held engineering firms have been overloaded with orders for more standardised products, and more recently the need to rearm must have drawn away the attention of designers to developments too secret to be put on view. No doubt those are amongst the reasons why fewer firms are exhibiting this year. But, in fact, we expect to find in reality that the Exhibition will prove to be just as interesting and just as instructive as ever. For novelty is not everything. We, indeed, have a special need to find it. For, because our space is limited, we need in our account of the Exhibition to make a degree of novelty a means of selecting what to describe and what not to describe. But we, nevertheless, recognise that to see the wholly new product is not necessarily more interesting than to observe the continuing development of the older. In fact, the greater part of engineering advancement has arisen not out of the application of new principles or of newly discovered scientific knowledge, but out of constant modification, minor in degree and dictated mostly by experience of devices in actual use. By the constant correction of minor faults, revealed in service, quite astonishing advances in performance and reliability come to be recorded as the years pass.

The flavour of the Olympia Exhibition is not to be fully savoured at a first experience. For a full appreciation the Exhibition must be visited biennially as the years roll by so that the memory can store up recollections and reflect how this product or that which made so much stir at a first showing has been tried, found wanting and disappeared, or how another, growing in technical esteem, has come at the last to be regarded as a conventional and ordinary device to serve its purposes. So by repeated visits we can come to recognise that the seemingly slow development of engineering design is also sure, so that tracing a line from the past it can a little way be projected, with some confidence, into the future. It is, indeed, this constant repetition of the experience, at an interval just long enough to make changes observable, yet not too long to permit forgetfulness to cloud the recollection of the previous Show, that makes the Exhibition valuable to firms which show their products and which, very many of them, biennially occupy the same stand in the same Hall. For whether or not the business they have done can, upon a narrow accountancy, be held to have justified the cost and labour and the loss of the valuable time of technical men attending the stand who might have been at work elsewhere, it is not possible to calculate with exactitude the high value of the goodwill created. The value of the show is not to be estimated in isolation on this or that year's experience in that regard. For the boy who moves around collecting pamphlets here and there this year will soon become the student more earnestly seeking technical information. A few years later, and riper in experience, his views, necessarily coloured by his familiarity with firm's products seen at Olympia in the intervening years, are likely to influence the buying policies of the firm he works for. Indeed, the responsibility for buying may soon be his. It is that continuity that makes the Olympia Exhibition specially valuable. It is, we feel sure, a value that the late Mr. Bridges had in mind when he decided to hold the Exhibition regularly and, by his beneficent acts, to make it not only a Fair, but also the technical and social event that it is.

INTERNATIONAL CONGRESS ON REFRIGERATION

WE have more than once speculated in these columns as to how much the lay citizen of a civilised state appreciates the high degree in which he depends for the maintenance of his high standard of living upon the work of engineers. No doubt his debt to engineers, should he bother to think at all about it, would be obvious enough to him when travelling by land, sea or air. It may be—more particularly, perhaps, when some fault occurs—that in using a telephone or watching a television screen, he has some vague conception of the technical skill that makes such devices possible. But is not ice cream to him just another food that he can buy? Does he not accept without further thought the arrival of meat, fruit, vegetables and fish in the shops? Is not the service of the domestic refrigerator taken as much for granted, once that device is installed, as the flow of water from a tap or the flood of light available (power cuts permitting!) at the

touch of a switch? Yet, in fact, with the domestic refrigerator there penetrates into the home a tentacle of an art and a science which makes it possible to bring fresh food from the ends of the earth to the kitchen stove and the dining table. It is an art and a science that has grown enormously in importance within this century until to-day probably as many engineers are concerned in refrigeration as in power generation, in keeping things cool as in making them hot! This week there opened in London the eighth International Congress of Refrigeration, the first such Congress to be held since the war. The first Congress of all was held in Paris in 1908, and two more were held before the first world war interrupted their sequence. Between the wars four more were held at four-yearly intervals from 1924 until that sequence was again interrupted by the second world war. The present Congress is being held under the auspices of the International Institute of Refrigeration, and has been organised at the request of the Joint Standing Committee of the Ministry of Food by the British Institute of Refrigeration. No doubt it will prove to be the first of a new sequence of such congresses.

Even to an engineer more adequately educated than the average citizen to understand how much his life is affected by the work of his brethren, refrigeration seems at first glance a by-way lacking the first-class importance to human existence of the supply of water, the generation of power, the provision of transport and the disposal of wastes. But a short perusal of the full programme of the Congress soon reveals that the making of things cold is just as valuable to the human race as the making of them hot; so much so, indeed, that upon a consideration of the papers that are being presented at the Congress, we are driven to wonder how mankind got on before refrigeration and before the mechanical power provided by heat engines! The main business of refrigeration, of course, is the preservation of foods. In his work the refrigeration engineer is thus brought into intimate contact with the work not only of growers and breeders, but of biologists, too, and he may need to understand, even if he does not deeply study, the changes, in nutritive value, for instance, that occur in foodstuffs in cold storage and to recognise and provide for the fact that some may be no more than chilled without damage, whilst others can be frozen. There is plenty of scope here for research, and development is rapidly continuing. Nor is food storage all, or nearly all. Refrigeration plays its part in other industries, in, for instance, the separation of gases by liquefaction, in engineering—soil freezing, for example—and in heating and ventilation, for people as well as foods can be air-conditioned! Moreover, on the more purely engineering side, in the making and operation of refrigerating plant, there are to be encountered technical problems just as interesting as those of heat engineering. Indeed, those problems, concerned as they are with insulation, heat transfer and conduction, not to mention compression to high degrees of pressure, have direct repercussions upon the work of engineers in other fields. Some idea of the scope of the Congress is given by the mere recital of the fact that between August 30th and September 4th more than 150 papers will be presented! They are not, of course, all being read in single sessions. Long ago it was found necessary to divide the Congress into seven "Commissions," dealing respectively with scientific problems and implications of the very low temperatures and of the rare gases; physical-technical problems of industrial refrigeration; fundamental biochemical and biophysical studies; refrigerating machinery, &c., and applications; refrigerated transport by water; and by land; and research, education, general economics, statistics and legislation. Even so, within each Commission the programme is a heavy one.

When propositions are put forward from time to time for the formation of this or that "international" body to hold regular "international" conferences we often feel sceptical of their value. For, in the exchange of much technical information across international boundaries, adequate means exist without the need to create many more formal bodies. But in refrigeration the need for the International Institute is made abundantly clear by one of the objects defined in the Convention by which it was created: "To collate and study all relevant laws, regulations and information concerning refrigerating industries, and if it seems desirable, to submit recommendations to Governments for the improvement and unification of regulations concerning the international distribution of those products to which refrigeration can be applied." Refrigeration is so much concerned with the transport of perishable goods and those goods so often have to cross international frontiers, that untold confusion could be created were regulations in different countries seriously to differ. Moreover, refrigeration is so much a technical matter—as, indeed, the scope of the Congress indicates—that in the drafting of regulations Governments need to depend upon the advice of technical bodies. It is, no doubt, for these reasons that in 1920, when an International Convention which set up the International Institute of Refrigeration was signed in Paris, no less than forty Governments took part and that a further fifteen have since joined the Institute. In our view, there have been since the war too many congresses, conferences and similar meetings. But this Congress is certainly not to be numbered amongst those which are supernumerary!

Obituary

J. P. CHITTENDEN

We have learned with regret of the death of Mr. J. P. Chittenden, which occurred on August 20th. His work in the field of steam turbine development will be well remembered by engineers. Up till the time of his retirement, through ill-health, in 1943, Mr. Chittenden had been chief turbine engineer at the Rugby works of the English Electric Company, Ltd., with which company and its predecessor, Willans and Robinson, he had been associated since 1906.

John Picton Chittenden was born at Blackheath, London, on June 14, 1881, and received his general education at Brook's House, Dover. He then studied for two years at the Crystal Palace School of Engineering before taking up an apprenticeship in the Vickers-Maxim works at Barrow-in-Furness. In 1904 Mr. Chittenden joined the drawing-office staff of the Wallsend Slipway and Engineering Company, Ltd., where he worked on the design of reciprocating engines. It was at that time that he became interested in the development of the steam turbine, particularly in its application to marine propulsion, and he was associated with the design of the turbines for the first "Mauretania" built for the Cunard Company.

Mr. Chittenden joined the drawing-office staff of Willans and Robinson (which subsequently merged in the English Electric Company, Ltd.) in 1906. Later, he became a member of the company's turbine design department, where he acted as assistant to Mr. E. G. Izod. Mr. Chittenden succeeded to the position of chief turbine designer in 1912, and in 1933 he became chief engineer and manager of the English Electric Company's steam turbine department. During his years with the company, Mr. Chittenden was mainly responsible for designing the first 30MW steam turbine, running at 3000 r.p.m., produced in this country, and also of the first turbine plant working with a steam pressure of over 1000 lb per square inch.

SIR ROBERT STEWART JOHNSON, O.B.E.

We announce with regret the death of Sir Robert Stewart Johnson, O.B.E., in his eighty-second year, at his home in Birkenhead, early on Tuesday morning, August 28th. Sir Robert, who was the chairman of Cammell Laird and Co., Ltd., the shipbuilders and engineers of Birkenhead, had been in failing health and only recently resigned his position of managing director on the advice of his doctors, who recommended a complete rest from business.

He was born in Castleblayney, County Monaghan, Northern Ireland, on August 7, 1870, and was educated at Foyle College, Londonderry. His early shipbuilding knowledge was gained in the shipyard of Harland and Wolff, Ltd., Belfast, and he remained in the company's employ until 1904, when he joined Workman, Clark and Co., also of Belfast, to take charge of the technical department. Under his influence the firm, which had been concerned previously only with building cargo vessels, began to construct passenger vessels, and Sir Robert's ability was recognised by the company making him the managing director.

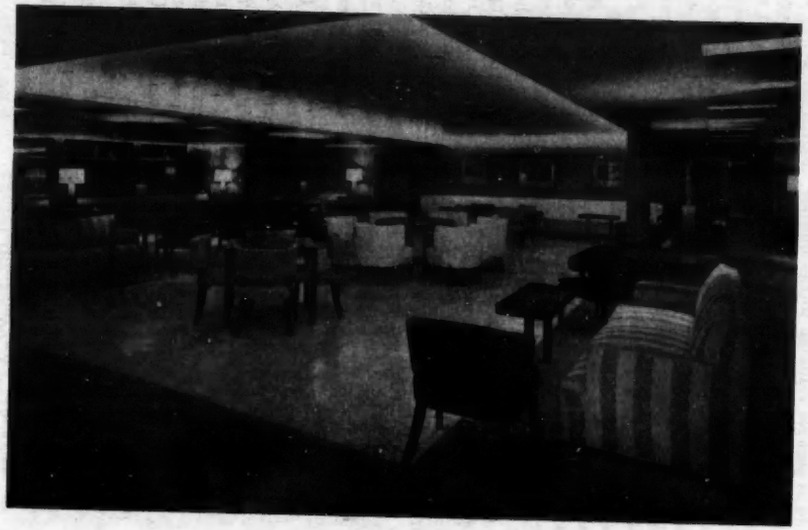
In 1920 Sir Robert began his long association with Cammell Laird and Co., Ltd., when he became a director and works manager of the famous Birkenhead shipbuilding and engineering company. Two years later, upon the death of Sir George Carter, K.B.E., he was made managing director, a position which he continued to occupy until a few weeks before his death. Following upon the death of Mr. W. L. Hichens in 1940, Sir Robert was elected chairman, and two years later received the honour of a knighthood, having been given the O.B.E. some time previously.

Although identifying himself so closely with Cammell Laird and Co., Ltd., he held a number of directorships in other companies, including, among others, the English Steel Corporation, Ltd., and the Metropolitan Cammell Carriage and Wagon Company, Ltd. He was a member of the Mersey Docks and Harbour Board for a number of years and served for some time upon the council of PAMETRADA, and at the time of his death Sir Robert was a member of the council of the British Shipbuilding Research Association and also of the executive board of the Shipbuilding Conference.

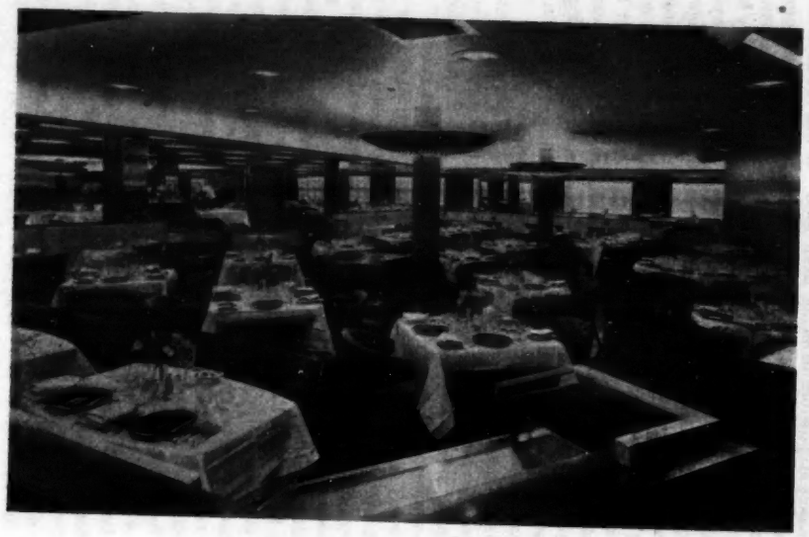
THE STEAMSHIP "INDEPENDENCE"

FIRST CLASS OBSERVATION LOUNGE

FIRST CLASS LOUNGE



CABIN CLASS LOUNGE



FIRST CLASS DINING SALOON

The Steamship "Independence"

FOLLOWING an initial Mediterranean cruise, the "Independence" has now entered her regular run between New York and the Mediterranean ports. Having exceeded 26 knots, the liner is the fastest merchant vessel built in the United States and is also the largest vessel to be completed in that country since the war. The keel of the vessel was laid on March 29, 1949, she was launched on June 3, 1950, and delivered on January 11, 1951. The liner was designed, built and engined by the Bethlehem Steel Company at its Quincy Yard, Massachusetts. The principal particulars of the "Independence," as well as those of her sister ship, the "Constitution," which recently sailed on her maiden voyage, were determined by her owners, the American Export Lines, Inc., while all interior decoration has been the responsibility of Henry Dreyfuss, one of the leading American industrial designers.

Dimensions and Particulars

Length overall	682ft 6in
Length between perpendiculars	632ft
Breadth moulded	89ft
Depth moulded to bridge deck	61ft 10in
Draught moulded to designed waterline	30ft
Displacement, total, at designed waterline, tons	30,090
Service speed, knots	22½
Gross tonnage	29,496
General cargo capacity, cubic feet	128,937
Refrigerated cargo capacity, cubic feet	55,198
Oil fuel, tons	8,100
Fresh water, tons	766
Accommodation:	
Passengers, three classes	1,003
Crew	577

Propelling Machinery:
Type: Twin-screw, double-reduction geared, cross-compound, impulse-reaction steam turbines.
Normal power: 37,000 s.h.p. at 134 propeller r.p.m.
Maximum continuous power: 55,000 s.h.p. at 150 propeller r.p.m.
Steam supply: 625 lb per square inch, 840 deg. Fah. at superheater outlet.
Boilers: Four Babcock and Wilcox, two-drum design.
Steam pressure: 660 lb per square inch.
Electrical machinery:
Four General Electric turbo-generators.
Rating 1100kW, 450V, three-phase, 60 c/s

Design and Construction

The pleasing profile of the new liner can be seen in the accompanying illustration, which shows that the vessel has a well-rounded superstructure front, tapered, tear-drop pattern twin funnels, a single mast situated just abaft the wheel house, and an overhanging counter stern, which is a familiar feature on vessels of the American Export Lines.

The hull and deck houses are built according to the highest classification of the American Bureau of Shipping, and welding has been used generally in assembling the double bottom structure, framing and girders, bulkheads, decks, deck-houses, and for other principal structural connections. The shell plating butts are welded flush, but the seams are riveted, and there are four riveted seams in the plating of the bridge deck and the promenade deck, which are the principal upper members of the hull girder. There are ten decks, eight of which are continuous, and fourteen watertight or oiltight transverse bulkheads, dividing the hull into fifteen major compartments, to provide a two-compartment standard of subdivision. Since overhead cranes of large capacities were available at the building berth, a considerable amount of prefabrication was carried out on the ground and then lifted into place on the berth.

Passenger Accommodation

Accommodation has been provided for a total of 1003 first, cabin and tourist passengers, and the 350 staterooms and twenty-one public rooms are situated on eight decks serviced by six main stairways, four passenger lifts and three service lifts. A feature of the passenger accommodation is the flexibility provided in the conversion of staterooms from one class to another to allow for varying passenger demands during different seasons, the design and decoration being devised so that there is little apparent difference between the classes of staterooms. All staterooms are air conditioned with individual control. First and cabin-class staterooms have private telephones and bath rooms, and are convertible from living rooms to bedrooms, and most first-class staterooms have polarised windows facilitating the individual control of glare and light.

De-luxe first-class suites and staterooms are situated on the sun and bridge decks, and other first-class staterooms are on the bridge, main and "A" decks. Cabin-class staterooms are on the bridge, main, "A" and "B" decks, while those for the tourist class are on "B" and "C" decks, and afford a greater degree of comfort for this class of travel than is generally provided on passenger liners. Convertible cabin-to-tourist class staterooms have a private shower and toilet, a convertible sofa-bed and fold-away berths, and all other tourist staterooms are equipped with basins having hot and cold running fresh water.

Convertibility in the promenade deck lounge is accomplished with floor-to-ceiling portable panels forming a bulkhead, while large multi-leaved folding doors convert the main deck social hall, and open deck spaces are converted with portable railings. An extensive shopping centre is available to both first and cabin class passengers. Three hospitals are provided, two on the main deck and one on "B" deck, and the main hospital, opening off the shop corridor, is fully equipped and accessible to all passengers and the crew. Just forward of the main hospital is an isolation hospital for passengers, while the crew's hospital is situated within the crew's quarters on "B" deck.

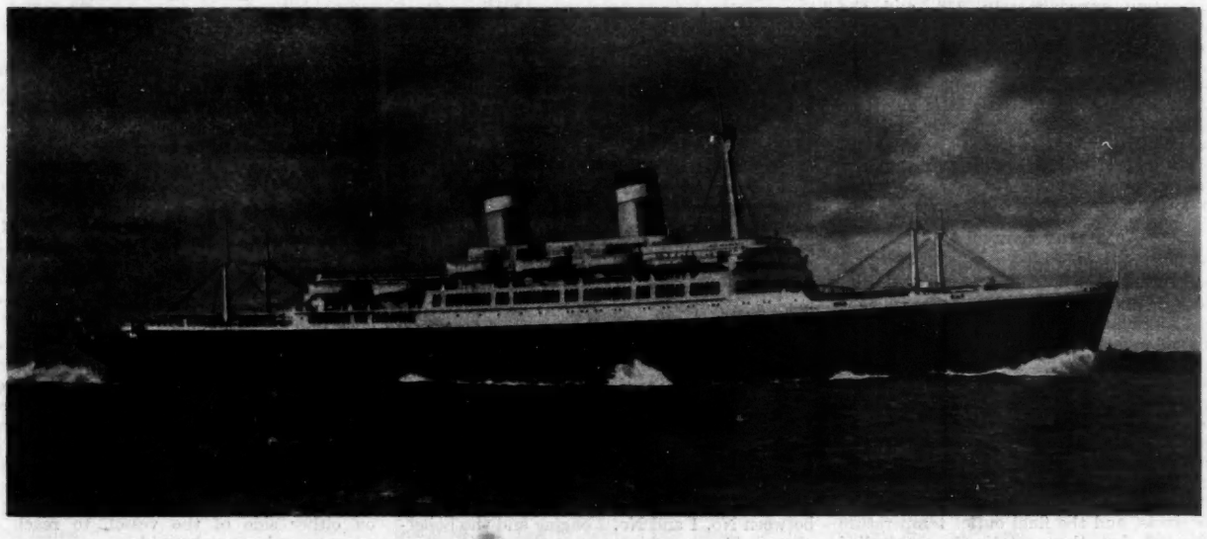
The captain and chief engineer, together with their senior assistants, are quartered on the sun deck forward, and the remaining deck and engineer officers have private staterooms on the boat deck. Steward and purser officers and the two doctors have staterooms adjacent to their offices. Deck and engine-room personnel are accommodated forward in four-berth cabins on the "A" and main decks, and the stewards are situated on "B" and "C" decks.

Public Rooms

The entire promenade deck is given over to public rooms, some of which we illustrate, which are arranged so that each room leads into the other with a continuity of theme, although each room is a complete entity with a distinct colour scheme and *décor*. The first-class observation lounge at the forward end of the promenade deck is semi-formal in appearance, and there is an extensive use of glass, with broad windows looking out across the enclosed promenade and covering about two-thirds of the walls of the circular room. The general appearance is one of lightness, both in the character of the furniture and the colour scheme, and in the centre of the room is a wooden dance floor.

Aft of the observation lounge is the first-class lounge, which has a modern *décor*, but includes historical features, the principal item being an enshrined replica of the Declaration of Independence of the United States which hangs over an antique carved eagle console in the centre of a large niche. Against the after bulkhead is a large pine cabinet, in which is displayed a collection of early American silver, pewter, glassware, chinaware and ceramics on loan from the New York Metropolitan Museum of Art. Further aft there is a play room for children to port and to starboard a dining room available for cocktail parties and private dinners. Continuing aft is the foyer to the first-class bar and cocktail lounge, and there is an oceanographic map painted on steel by Lawrence Kupferman, on which magnetic ship symbols show the daily position at sea, seven clocks around the map showing the ship's time as well as that in various cities throughout the world. Cut into the after bulkhead of the foyer is a $\frac{1}{16}$in scale model of the original United States Navy vessel U.S.S. "Independence."

The "Boat 'n Bottle" bar, which is so named because of a display of forty hand-



T.S.S. "INDEPENDENCE"

blown bottles in each of which is a miniature model of a sailing ship, consists of two rooms and serves as a cocktail bar, a lounge for card playing and as a night club. The "Sea Island Club," on the sun deck aft, combines the first-class swimming pool and the pool cafe, and provides a considerable amount of open deck space for recreation and relaxation, about 25 per cent of which is shaded. On either side of the pool, decks extend aft providing shade for the sun deck, and being wide enough for deck chairs may be used for observation of the pool or for sun bathing. Forward of the pool are the glass-enclosed cocktail lounge and the soda bar, which form the pool cafe.

The principal public rooms for cabin-class passengers are situated on the bridge deck aft. The lounge is a bright and colourful room which accommodates about 130 people, and has a central dance floor, while the cabin-class bar, a semi-circular room, is a modern adaptation of an historical American inn, the dominant feature being a mural, behind the bar, which shows a forest of spars, masts and rigging typical of an eighteenth and nineteenth century port. Surrounding these two rooms is an enclosed promenade with doors leading aft to the swimming pool and the games deck.

The tourist-class public rooms, a convertible cabin-tourist class social hall, and the entrance foyers for all classes of passengers, are on the main deck. Also on this deck are a gift shop, a beauty parlour and the barber's shop. On the port side aft of the social hall is another children's room, which may be converted for either cabin or tourist-class accommodation. Further aft is the entrance foyer from which tourist-class passengers may have access to the social hall. Beyond are the tourist-class public rooms, comprising a lounge and a bar, and on the open main deck aft, which is used for tourist-class recreation, is a salt-water cascade recessed into the 'midship house.

All dining saloons are on "A" deck, with one large galley amidships for the first and cabin-class dining saloons, and another smaller galley aft to serve the tourist dining saloon. In the first-class dining saloon, which can seat 300, the centre section of the deck is dropped below normal deck level to gain height and to form terraces on three sides, and the main decorative feature is a large mural which depicts the entrance to Boston Harbour as seen from the sea. Aft of the galley is the cabin-class dining saloon, a spacious room in red and dark green, seating approximately 236, and the tourist-class dining saloon is an "L" shaped room along the port side of the ship. On "C" deck aft and running athwartships is the auditorium, which is decorated in blue and gold, has a seating capacity of 150 and is available for religious services, ship's concerts, and for use as a cinema. Against the starboard bulkhead is a projection booth with two standard motion picture projectors for rear projection to the portable screen on the stage.

Auxiliary Services

The air-conditioning installation provides for the control of temperature and humidity in all accommodation, and there are twenty-eight systems supplying a total volume of more than 195,000 cubic feet of air per minute. Three of these systems serve the dining saloons, eight serve other public rooms, and seventeen serve the passengers' staterooms and the crew's quarters; those systems which serve the dining saloons take outside air only, while the other systems are arranged for partial recirculation. In normal operation, conditioned air at relatively low temperature is distributed through the air ducts, and the final outlet temperature is adjusted by thermostatically controlled reheaters, which are situated just ahead of the diffusers for each room. Individual room thermostats may be set to suit the requirements of the occupant. The designed room temperatures in summer are 80 deg. Fah. dry bulb and 67 deg. Fah. wet bulb, with an outside temperature at 95 deg. Fah. dry bulb and 80 deg. Fah. wet bulb. In winter, the heated spaces are designed to be maintained at 70 deg. Fah. dry bulb with the outside temperature at 0 deg. Fah., and the dehumidifying coils are designed to extract water from the air at rates up to 3400 lb per hour.

There are two "Carrier" refrigerating plants for air-conditioning purposes, consisting of two-stage "Freon 11" compressors driven at 5600 r.p.m. by 1750 r.p.m., 500 h.p. motors through speed-increasing gearing. This machinery is located on the port side of the auxiliary machinery room, and is designed to cool 1680 U.S. gallons of fresh water per minute from 53 deg. to 41 deg. Fah. Recording temperature controllers actuate pneumatically operated automatic suction dampers and control the compressor capacity in accordance with load demand. The plant is designed for single compressor operation under light load and dual operation at times of heavy cooling loads. Chilled water is circulated from either or both of the "Freon 11" cooling plants to cooling coils in parallel with each other by a simple supply and return piping circuit. Two motor-driven centrifugal pumps, arranged in parallel, are situated adjacent to the coolers, and balancing flow meters are placed in the chilled water circuit of each fan room. Where there are multiple chilled water circuits, individual balancing valves are provided for each cooler in addition to the master balancing valve. The cooling coils, which consist of finned copper elements enclosed in heavy galvanised casings fitted with special drip pans, are designed for a surface velocity not greater than 500ft per minute, and all coils, with the exception of those serving the three dining saloons, have six rows of finned tubing in the direction of the air flow. Due to the heavy latent heat load in the dining saloons, the coils serving these spaces have eight rows of finned tubing. The design is based on an exit air temperature for the three dining saloon systems of approximately 52·8 deg. Fah. and for all other systems of approximately 57 deg. Fah. For the reheating of conditioned air, there are seven independent hot water circuits, each being provided with its own steam heater and circulating pump. The circuits, in general, are of two-pipe reverse return design and supply the air-conditioning terminal reheater coils and convector radiators throughout the vessel with water at a temperature of about 220 deg. Fah. The water temperature of each hot water heater is regulated by a pneumatically-operated steam valve under control of a sub-master thermostat with its bulb placed in the heater discharge, and a master thermostat, with its bulb situated in the weather, is arranged to reset the control temperature of the sub-master units according to changes in outside temperature. Steam is supplied to all preheaters, certain reheaters, all convection radiators and all air-conditioning hot water heaters from two steam heating systems, operating respectively at 12 lb and 35 lb per square inch.

Mechanical ventilation supplies air to the galleys, auxiliary machinery compartments, steering gear space, fan rooms, windlass and capstan motor rooms, the wheel-house, battery rooms, workshops, laundries and similar spaces. Each of the two main machinery rooms are ventilated by four 20 h.p. axial supply fans having a capacity of 30,000 cubic feet per minute, and four 15 h.p. axial exhaust fans with a capacity of 35,000 cubic feet per minute. The auxiliary machinery room is ventilated by a mechanical supply system of 25,000 cubic feet per minute capacity and a mechanical exhaust system having a capacity of 27,000 cubic feet per minute.

The refrigerating machinery for the main ship's stores is situated below the refrigerated compartments in the auxiliary machinery room between No. 1 and No. 2 engine and the boiler-room. The machinery for the tourist-class refrigerated stores is situated aft in the shaft tunnel. The main plant consists of two "Carrier" four-cylinder, belt-driven compressors, one driven by a 60 h.p. motor and the other driven by a 30 h.p. motor. The refrigerating machinery for the tourist-class stores consists of two 25 h.p., direct-connected, four-cylinder "Freon 12" compressors, which are provided with automatic cylinder unloading and capacity control.

Four compressor units, similar to those used for the refrigerated stores, serve the six refrigerated cargo compartments, each compressor being belt driven by a 60 h.p. motor and discharging to condensers having 400 square feet of effective surface. The refrigerated compartments are cooled by recirculated air which is chilled to the desired temperature by direct expansion cooling coils under control of liquid line solenoid valves and return air thermostats. The plant is capable of maintaining temperatures at any level between 0 deg. and 50 deg. Fah. in the refrigerated cargo holds.

The vessel has six main fire-zone bulkheads, together with other intermediate fire-resistant bulkheads and decks. Insulation of these bulkheads and decks depends on the contents and use of the spaces, and is in accordance with the latest regulations of the U.S. Coast Guard. Detection and alarm facilities used on board the ship include an electric alarm system with about eighty manual alarms, 700 thermostats which register by zones in the fire-control room and by bells in the engine-rooms and the emergency crew's quarters; watchmen's hourly patrol; a smoke-detecting cabinet in the fire-control room, connected with cargo spaces and boatswain's stores; general alarm bells throughout the ship operated from the wheel-house, and an emergency broadcasting system with the microphone in the wheel-house.

There are thirty-five power-operated horizontal sliding watertight doors, each of which has its own hydraulic system, consisting of a direct-acting cylinder, a motor-driven pump unit, hand-operated pumps adjacent to the door, a hand pump for remote control from an emergency station above the bulkhead deck, hydraulic oil supply and surge tanks, and a segmented valve block containing check and relief valves and a pressure switch. Each door may be power operated, through an electrical circuit, from the navigating bridge, and also by means of push buttons at the door itself, while individual doors may be opened locally for purposes of escape, and then will close again automatically. The hydraulic pumps are of rotary design, reversible for selecting the direction of door motion, and operation is fully automatic once a pump has been started. A pressure switch stops the pump motor when the door is fully closed and a limit switch stops it when the door is opened by power, while relief valves protect the system when the hand pumps are used.

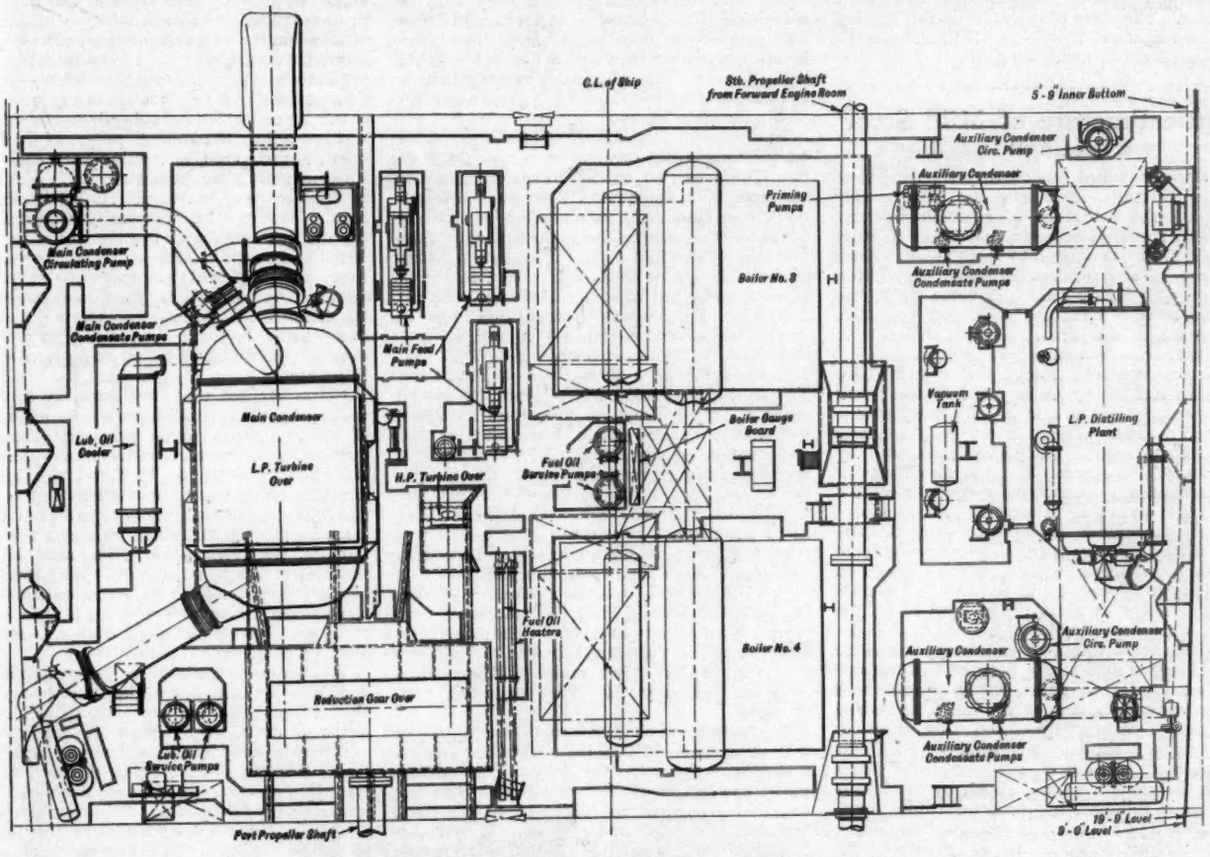
Deck Machinery

Although primarily a passenger ship, there is space for the stowage of approximately 2500 tons of general and refrigerated cargo. In the three holds, served by weather deck hatches, cargo is handled by eight 5-ton derricks, and two 2-ton derricks are provided aft for loading mail and packaged cargo in No. 7 hold through the side ports. Alternatively, conveyors from shore may load cargo directly through these ports, and two electric cargo conveyors have been fitted to transfer cargo between No. 7 hold and the loading point on "B" deck. Holds Nos. 3 and 4, intended to carry refrigerated cargo, are reached through the side ports on "A" deck, and to handle this cargo across "A" deck and in the hatches which lead from that deck to the refrigerated holds two "Siporters" have been fitted. These machines were developed by the Lake Shore Engineering Company of Iron Mountain, Michigan, in co-operation with the U.S. Maritime Administration, and each unit consists essentially of a d.c. electric hoisting carriage which travels athwartship over the hatchways on beams which can be extended, through the cargo ports on either side of the vessel, to reach over wharves or barges alongside.

The twelve cargo winches for the 5-ton derricks are driven by 50 h.p. d.c. motors, and four similar units, driven by 25 h.p. motors, are provided for the 2-ton derricks. There are two electric windlasses on the bridge deck driven by 85 h.p. d.c. independent power units mounted on the deck below, provision being made for cross connections between the power units and the windlass shafts for emergency use. Each windlass motor also drives a capstan head through a separate power take-off and gearing.

There are five mooring capstans, two forward and three aft, each driven by a two-speed, 35 h.p. a.c. reversible motor through 4 to 1 speed-reduction gearing.

The steering gear is electro-hydraulic, and has four rams in two opposing pairs, which act through a rapson slide upon a tiller secured to the rudder stock. The unit has a full follow-up differential control, including a torque equaliser which limits the power input and reduces the speed of turning at the higher values of rudder torque. Conversely, the rudder is turned more quickly when the ship is manœuvring at reduced speed. Two motor-driven pumps are provided, one acting as stand-by, and each is driven by a 75 h.p. a.c. constant-speed motor. Normal steering control is by an electrical self-synchronous system from the steering wheel on the navigating bridge or by gyro-pilot. A steering pedestal on the top of the wheel-house connects mechanically with that in the wheel-house, and a steering wheel on the bridge deck aft has direct mechanical connection with the pump controls in the steering gear compartment.



MACHINERY ARRANGEMENT AT 9FT LEVEL OF AFT ENGINE ROOM

PROPULSION AND AUXILIARY MACHINERY

The normal shaft horsepower of the propelling machinery is 37,000, which will give a sea speed of 22½ knots at 30ft draught. The designed maximum continuous shaft horsepower is 55,000, based on requirements as a naval auxiliary. At 22½ knots and 30ft draught, the maximum cruising radius of the vessel is 19,000 nautical miles.

There are two complete engine and boiler-rooms, separated by a watertight auxiliary machinery compartment, thus eliminating the possibility of flooding both engine-rooms by the penetration of one watertight bulkhead, and one set of machinery can drive the vessel at approximately 80 per cent of the normal speed of 22½ knots. The arrangement of engine and boiler-room is reproduced in the accompanying drawing. The entire installation and its component parts were designed with an emphasis on reliability and economic maintenance. The steam cycle combines high efficiency with simplicity of operation, and permits the use of standard materials for piping and pressure parts. Steam is supplied by four Babcock and Wilcox two-drum, bent-tube, air-cooled, marine water-tube boilers fitted with superheaters, air heaters, auxiliary steam desuperheaters, water walls, steam drum attemperators, and oil burners with mechanical atomisers. The boilers are designed to generate steam at 660 lb per square inch, and each unit evaporates 77,500 lb of steam per hour with a superheater outlet pressure and temperature of 625 lb per square inch and 840 deg. Fah. respectively, and with a feed water temperature of 330 deg. Fah. Under these conditions, each boiler burns oil at the rate of 5350 lb per hour, while the designed maximum rate of evaporation is 125,300 lb of steam per boiler per hour. The overall fuel consumption, including the hotel services and the distilling plant is 0·58 lb per shaft horsepower per hour at normal power rating. Each boiler has a generating and water-wall surface of 9200 square feet, a superheater surface of 1035 square feet, and an air heater surface of 6260 square feet. Water cooling is employed in the furnace side, roof and rear walls. The convection superheater is mounted with the headers at the rear of the boilers, with tube withdrawal into the firing aisle. The air heaters are of horizontal tubular design utilising one gas and two air passes, the air entering and leaving the air heater at the front of the unit and flowing through the front double casing to the oil burners. Air by-pass dampers are installed for use in port. The drum attemperator on each boiler is used in conjunction with a manually-operated control valve to permit full load operation with satisfactory steam total temperatures, should low feed water temperature conditions be encountered. All of the steam leaves the superheater at the outlet of the second superheater pass, and with the valve open part of the steam flows through a by-pass line to the inlet of the third pass, while the remainder flows through the attemperator and valve and mixes with the by-pass steam before entering the third pass of the superheater. The quantities of steam flowing through the by-pass and attemperator lines are proportioned to obtain the necessary reduction in the high steam temperature which would otherwise be obtained with low feed water temperature conditions.

The cross-compound, impulse-reaction turbines are flexibly coupled to double-helical, double-reduction gearing driving a three-bladed propeller. Each turbine set comprises one low-pressure turbine, and consisting of twenty reaction stages with two impulse stages in the astern section, while the high-pressure unit consists of one impulse and twenty reaction stages. At normal rating the high-pressure unit operates at 4227 r.p.m., and the low-pressure unit at 2104 r.p.m. Exhaust steam from each turbine is condensed in a horizontal, single-pass reheating condenser producing a vacuum of 28·5in at normal power when supplied with 34,000 U.S. gallons per minute of sea-water at 75 deg. Fah. Each condenser has a cooling surface of 16,000 square feet. For port use, going astern and low speeds ahead, a motor-driven circulating pump is provided, while for speeds above 10 knots circulating water is taken from the sea by a scoop.

The main reduction gears have a pitch diameter of 174·7in and weigh 63,000 lb. The main Kingsbury thrust bearings are integral with the reduction gear cases, and each transmits a force of approximately 293,000 lb at maximum power. In each engine-room all main auxiliaries, including turbo-generators, feed pumps, fuel oil service pumps, condensate pumps and lubricating oil pumps, are fitted in duplicate.

The vessel has a single fresh-water system to serve all purposes, the water being distilled from sea water by two vacuum double-action distilling plants, each having a rated capacity of 120,000 U.S. gallons per day of fresh water. The shells are of welded cupro-nickel alloy plate and cupro-nickel is used for the heat exchanger tubes.

Electrical power is supplied by four three-phase, 60 c/s turbo-generators, each having a capacity of 1100kW at 450V a.c., one diesel-

driven three-phase, 60 c/s emergency generator with a capacity of 150kW at 450V a.c., and one set of storage batteries, for emergency use, able to deliver 73kW for one and a half hours at 240V d.c. The distribution of electricity for lighting makes use of 450V feeders from the generators to each of the fire zones, and within each fire zone a local distribution panel connects the current to individual lighting circuits at 117V a.c. The diesel generator and the storage batteries provide power at 117V for general safety, emergency lighting and navigational requirements in case of failure of the normal supply from the turbo-generators. To provide for the special electrical requirements of the d.c. deck machinery, two 200kW, 240V motor generator sets have been installed. There are also two 30kW, 120/240V motor generator sets for battery charging purposes and miscellaneous d.c. needs. Two 5kW, 117V, single-phase, a.c. motor generator sets supply a.c. from the storage batteries, where required for interior communication, alarms and various emergency systems. The total electrical load for lighting purposes is about 750kW at 115V, and for the galleys it is about 500kW at 220V.

Brittle Fracture of Mild Steel*

By T. S. ROBERTSON, M.Sc. (Eng.)

SINCE the end of last century the subject of brittle fracture in steels has increasingly occupied the attention of research workers. It is only recently, however, that brittle fracture of mild steel has come into prominence. First, collapse of a bridge in Belgium, then later, catastrophic brittle failure in some ships, has set in motion one of the largest collective researches of our time, on the Continent, in the United States, and in this country.

Till comparatively recently, tests have been of a simple character, Charpy or Izod test pieces being accepted as standard. The early assessment of notch brittleness in terms of the energy required to fracture was probably dictated by its ease of measurement in the two forms of test named, but criteria of assessment remain a very lively source of controversy even to-day.

Early researches by Stanton and Batson[1] established that by increasing the velocity of an impactive blow, transition from tough to brittle type fracture could be produced in mild steel. Later, Docherty,[2] by increasing the speed in slow-speed notch bend tests produced a transition from tough to brittle type fracture in cold drawn mild steel. Stanton and Batson[3] demonstrated that geometrically similar test pieces showed a size effect under impactive loading. Docherty[4] produced this effect in geometrically similar slow bend notched test pieces, and attributed it to transition from tough to brittle fracture. Lea[5], by overstrain in tension followed by low-temperature heat-treatment, produced a transition from tough to brittle fracture in mild steel by varying the amount of overstrain.

In the recent speed up in research into brittle fracture, changes in test procedure have been introduced. Many investigators now prefer a test on full plate thickness and some insist that a symmetrically notched tensile test piece is essential to simulate practical conditions of stressing in plates. Generally, however, test for brittleness follow one main pattern; a notched test piece is pulled or bent until, after some degree of straining, a crack propagates from the notch. The nature of the crack can be changed from tough to brittle by controlled variation of chemical composition, heat-treatment, size of test piece, speed of testing, the temperature at which the test is carried out, &c. Thus the change from tough to brittle fracture is determined by a number of features, many of which are conditioned by the analysis and mill history of the steel before testing, and others by the mode of carrying out the test. Temperature change produces a transition from tough to brittle in mild steel and, being easily controlled, has been adopted as a standard means for investigation. Much controversy centres round the criterion for assessment of results. Three main criteria are used, namely, energy to fracture, appearance of fracture and local contraction of the section at fracture. These three criteria do not always give the same temperature transition ranges, nor do different types of test give the same ranges on one steel when the same criterion is used, but it is generally agreed that transition temperature tests put the materials tested in the same order of merit. The temperature ranges established bear no relation to those in which the material will break brittle in practice. Thus, the designer is given an order of merit for the materials he has available, but has no information whatever as to what design stress he should adopt to safeguard the structure from catastrophic brittle failure or at what temperature he may expect trouble from brittle fracture.

A study of accounts of catastrophic failures indicates that there are two stages in such fractures. First, somehow or other, a crack must be started, then second, this crack must propagate with extreme speed through the structure. Although high local stress may be associated with the first part, there is evidence that continued propagation may take place at low nominal stress of value about 5 tons per square inch. This continued propagation at low nominal stress is the most important feature of catastrophic failure.

In a research into the effect of sharp notches on the temperature transition ranges for three mild steels carried out at Naval Construction Research Establishment, Tipper notched tensile tests were made. The steels were an ordinary commercial mild steel bar 1¼in square, a shipbuilding steel plate 1¾in thick, and a heavy stiffener 2in thick that had broken in brittle manner under test at atmospheric temperature. The bar had a temperature transition range on energy assessment covering +20 deg. to +60 deg. Cent., the plate −40 deg. to +20 deg. Cent., and the stiffener −20 deg. to +40 deg. Cent. To produce a really sharp crack, a second series of Tipper pieces cut from the three steels had shallow notches cut in them and were then each subjected to about 250,000 cycles of bending fatigue stressing until the fatigue cracks, started in the notches, had reached normal notch depth. On testing these pieces as in the normal Tipper test, the bar gave a transition range, on energy assessment covering −5 deg. to +15 deg. Cent., the plate −5 deg. to +15 deg. Cent., and the stiffener +40 deg. to +95 deg. Cent. That the transition temperature range was lowered in the bar, little changed in the plate and raised in the stiffener provides evidence that, under this treatment at least, certainly the order of merit was changed.

In the tests on the three mild steels, plots of maximum stress reached before fracture provide a startling contrast. The fatigue cracked test pieces each showed a loss of strength over the transition range of the order of 40 per cent, whereas, with standard notches, the strength increased continuously with fall of temperature in the bar and in the plate. In the stiffener, however, there is a fall of about 20 per cent in strength near the bottom of the energy transition zone. It would appear, therefore, that the stiffener is brittle enough to exhibit a loss of strength at low temperature with a standard notch and that the temperature at which this loss of strength occurs is raised by the sharp fatigue crack.

If a sharp crack results in loss of strength then the very sharp crack present during the propagation of brittle fracture will possess the very properties necessary to explain why ships have broken in two at nominal stresses of quite low value.

Microscopic examination of the broken fatigue cracked notched tensile test pieces shows that there was considerable yield in the material at the root of the fatigue crack, but very much less yield, if any, in the material through which the brittle crack propagated at temperatures below the transition range. Thus, tests using machined and even fatigue notches introduce a large degree of artificiality that may mask those properties that lead to catastrophic failure. The idea was conceived that, if a propagating crack could be started at very low temperature in a test piece of varying brittleness, the capacity of the material to resist crack propagation could be studied.

A test piece was devised which met this requirement. It was in the form of a full thickness strip, flame cut from a plate. It was 8in long and 2in wide, with one end cut semi-circular. Near this rounded end a 1in diameter hole was drilled centrally in the width so as to leave ¼in thickness of metal under the radius. A jeweller's saw cut ⅛in deep was made centrally in the width on the side of the hole remote from the radiused end. The specimen was clamped flat on a thick piece of asbestos with its end hard against a heavy stop. It was cooled by pouring liquid nitrogen at a controlled rate into the hole. By this means a temperature gradient was established along the length of the specimen to achieve a variation in brittleness. The temperature was measured by a thin flat thermocouple held in contact with the specimen at successive ¼in marks. When the temperature had reached a steady value, the crack was started at the notch and propagated into the material by a rapid series of blows on the rounded end from a heavy pneumatic riveting hammer. It was found that for mild steels a temperature of at least −70 deg. Cent. at the saw cut was necessary to start a crack there, which would propagate without surface yield. This crack propagated rapidly into the test piece, advancing with each blow till eventually it stopped, when continued blows resulted in the yield of the material round its root. This yielding was easily recognised on the polished surface of the test piece, and was found to be reproducible at the same temperature for different temperature gradients arranged by warming up the remote end with a gas flame. In general, this temperature was found to be low compared with that at which some of the material tested had given trouble in practice.

It was realised that each blow, by driving a wedge of yielded material into the rounded end of the test piece, would propagate the crack only so far as the stress at the root of the crack was high enough to continue propagation. Therefore, this test showed arrest of the crack at a low temperature that represented conditions for propagation at an unknown minimum value of transverse stress. The next development then was to arrange that a known value of transverse stress should be maintained during the test and to dispense with the series of blows, replacing them by a single blow necessary to start propagation.

The transverse stress is easily applied by welding the test piece into two heavy lugs that carry holes for pins for attachment to shackles in a very simple testing machine which uses a hydraulic capsule to apply the load. Intermediately between the lugs and the edges of the test piece, two strips of thinner material are interposed. On assembly in the testing machine a load sufficient to yield the strips is applied. This ensures that stored stresses in the welds will be relieved, and that the plastic deformation will produce a uniform stress distribution along the test piece. The length of the test piece has been increased to 12in to give an operative length of 10in and the width to 3in to allow preparation for welding. After the mechanical stress-relieving process, four Huggenberger extensometers are attached, two on each side of the test piece at quarter-length points. Load is applied and the stress and its uniform distribution are verified. The extensometers are removed and brass caps are attached to each side of the now horizontal hole in the test piece by a through bolt. Liquid nitrogen is poured at a regulated rate into one cap, passes through the hole as it evaporates and escapes to atmosphere by a bent in the other cap. A small flat-flame gas burner is used to heat the other end of the specimen. After about twenty minutes the temperature gradient along the test piece has reached a steady value and it is measured and check measured by thermocouple, the value −70 deg. Cent. at notch and +60 deg. Cent. at the remote end being usual values for a normal mild steel. The gradient is about 10 deg. Cent. per inch at mid-length. The appropriate transverse load is now applied and a bolt gun

* British Association, Edinburgh. August 14th.

is inserted into a guide carrying a trapped plunger that contacts the rounded end of the specimen. The movement of this plunger is limited to ¼in.

The gun is fired, and a crack, started at the notch by the impact, immediately propagates along the length of the specimen into zones of gradually increasing temperature till it stops. The speed of this crack is such that for the usual travel of about 6in, high-speed photography at 4000 frames per second is too slow to record it. The crack appears full length in the space of one frame. This means that the speed of propagation of the crack exceeds 2000ft per second and is probably much higher, since no film so far has shown a crack in process of development in the frame adjacent to the one with an arrested crack. At such a high speed of propagation there is not time for the relaxation of stress initiated by the crack to have reached the uncracked part as increased tension before the crack has stopped. The nominal stress in the material into which the crack propagates must therefore remain substantially unaltered. Soon after the crack has stopped the increase of stress follows and extensive yield of the material round the root of the crack takes place. The temperature at which yield took place is best determined after cutting open the specimen to reveal the fractured surfaces. The two halves show a characteristic thumb-nail marking where the brittle fracture stopped. The focus of this marking is used to identify the temperature at which arrest took place and yields consistent results for the same material tested at the same stress with different temperature gradients. Characteristic results are as follows :—

Letter	Material	Transverse stress, tons/sq. in	Crack arrest temperature. deg. Cent.
A	1in plate	15	12
	0·20% C	13	10
	1·44% Mn	10	10
		7½	10
		5	−36
B	1in plate	15	− 5
	0·13% C	13½	− 5
	0·97% Mn	12	−42
C	1in plate	10	20
	0·31% C	7½	20
	1·32% Mn	5	−45
D	½in plate	10	8
	0·23% C	7½	7
	1·02% Mn	5	−35
E	½in plate	16	−10
	0·23% C	15	−20
	0·87% Mn	10	−22

An examination of the foregoing results shows that, as the transverse stress is reduced, there is a sudden drop in the temperature at which the propagating crack is arrested. This is, in fact, a strength transition which, in most of the materials tested, occurs at a low stress value of the order of 5 tons per square inch. The temperature at which the crack is arrested varies little with increase of stress above the transition. Steel B is outstanding, especially in the strength transition. The stress of 12 tons per square inch is high enough for most applications for a mild steel and, even above this stress, the critical temperature of −5 deg. Cent. is low in comparison with values obtained from other samples, excepting, of course, the thin plate. It is evident that the test substantiates the lower transition temperature generally agreed for thin plates, but there is, no doubt, a strength transition also for thin plates. Below the strength transition, the temperature for arrest of the crack falls to a low level seldom met with in practice.

This suggests that the designer can now be given a safe stress below which there is no chance of brittle fracture at ordinary working temperatures.

An examination of many fractures produced by the new method shows that very often a second brittle fracture occurs in the yielded material after the first arrest. It has been established by others that the transition temperature of mild steels is considerably raised by yielding, the rise being more marked if the yielded material is aged for a few days before testing. That there is evidence sometimes of one, even two or three, successive brittle cracks through the yielded material, each with an arrest and subsequent yield, indicates that yield *per se* must raise the brittle temperature considerably. In this lies an explanation of the width of transition temperature bands resulting from other forms of brittleness test. The criteria of lateral contraction and of energy involve yield prior to fracture at a series of increasing temperatures. Those test pieces with higher contraction or energy than the minimum yield more, and eventually yield enough, to fracture in brittle fashion at the temperature of test. Extension of the transition range to lower temperatures is due to the use of a notch of sharpness less than that of the natural notch provided by a propagating crack. Fissures that open at the root of a machined notch during the progress of a test complicate matters, and, allied with the phenomenon of yield embrittlement can account for the stepped transition curves that have recently occupied much space in the literature on brittle fracture in America.

A deposited weld bead produces a heat-affected zone which will start a sharp crack at the root of a notch after a small amount of yield. Tests that employ this means for starting fracture naturally show a rise in transition temperatures over unwelded plates, but it is still evident from an examination of fractures that considerable tearing of a ductile nature may take place in the material adjacent to the heat-affected zone during the higher temperature tests, before yield has progressed far enough to cause brittle fracture in the remainder of the material. Again, the adoption of a criterion of 2 per cent lateral contraction before fracture insists that the crack shall pass through yielded material. To infer from tests on yielded material how to avoid catastrophic failures by brittle fracture through unyielded plates at low nominal stress levels is open to criticism, but the new test simulates the practical conditions of actual fracture, and it is confidently hoped will contribute to the solution of the problem of brittle failure in mild steel.

This account is published with the approval of the Lords Commissioners of the Admiralty, but the responsibility for any statements of fact or opinions expressed rests solely with the author.

The author is indebted to the Superintendent, Naval Construction Research Establishment, where this work was carried out, for encouragement and advice during the development of the test. Thanks are also due to Mr. G. A. Keay, B.Sc., Chief Metallurgist at the above establishment for much help in discussion of the metallurgical aspects of the test.

REFERENCES

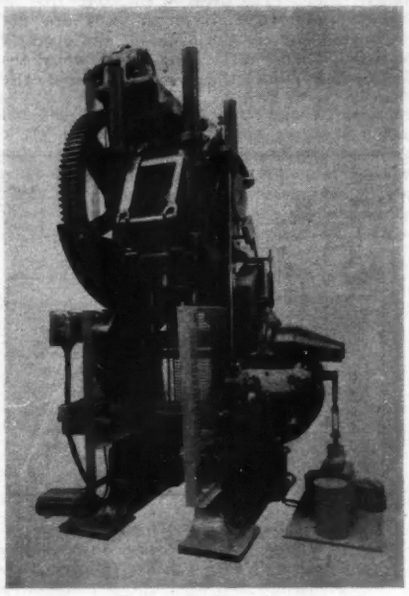
1 " Min. Proc.," Inst.C.E., 211, page 81.
2 *Engineering*, Vol. 131, page 347.
3 " Min. Proc.," Inst.C.E., 211, page 75.
4 *Engineering*, Vol. 139, page 211.
5 " Min. Proc.," Inst. Mech.E., 1935.

Corrosion of Buried Metals

A NEW standard form for recording corrosion failures of buried pipes has been prepared by the British Iron and Steel Research Association's Sub-Committee on the Corrosion of Buried Metals. It is available from Mr. E. E. White, B.I.S.R.A., 140, Battersea Park Road, London, S.W.11, and is to be returned when completed to the Chemical Research Laboratory of the D.S.I.R., Teddington. The sub-committee has taken over from the Research Co-ordination Committee of the Institution of Water Engineers its work on the corrosion of buried pipe-lines, and the new form incorporates the changes which the Institution's experience has shown to be desirable. The seriousness of the problem of underground corrosion, which has been estimated to cost the country £5,000,000 per year, was recognised in the report of the Ministry of Health's Departmental Committee last year, where the importance of full and accurate records of all cases of underground corrosion was emphasised.

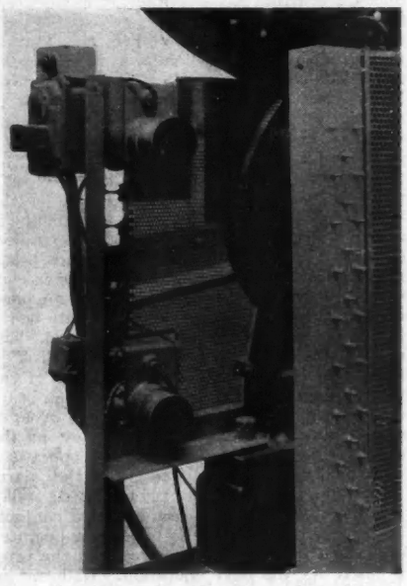
Electronic Press Guard

A NEW design of automatic guard for power presses and similar machines has been developed by the Witton-Kramer works of the General Electric Company, Ltd., and a prototype equipment fitted to a Taylor and Challen press was recently demonstrated at a Safety Exhibition organised by the Birmingham and District Industrial Safety Group. This press, complete with its electronic guard, is illustrated



PRESS FITTED WITH ELECTRONIC GUARD

herewith. An important characteristic of the new guard, which occupies less space than the usual mechanical guard, is that the operation of the electronic equipment is automatically checked at each complete stroke of the press, so that immediate warning is given should any fault develop in the system, thus preventing



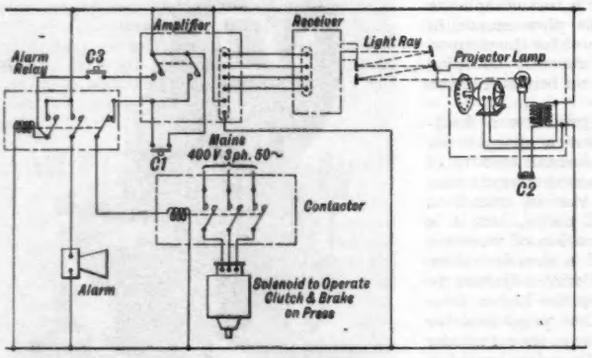
PHOTOELECTRIC EQUIPMENT FOR ELECTRONIC PRESS GUARD

the operator from continuing to work under a false sense of security.

As illustrated, the equipment is mounted on vertical angle iron columns fixed at each side of the front of the press. A lamp house at the top of one column projects a beam of light

across the front of the press to a mirror on the opposite column; the beam is then reflected to and fro by a series of mirrors until the whole area between the columns is traversed by the beam, forming a barrage of light rays.

The light beam is reflected by the last mirror into a receiver unit comprising a photo-electric cell and an amplifier. A relay in the output stage of the amplifier interlocks the operation of the press to ensure that it cannot be worked whilst any part of the operator is interrupting the light beam and is in consequence in the danger zone. The press is therefore free to operate only when the light rays are not obstructed and, in the event of the operator placing his hand in the danger zone whilst the tool is descending, the press is automatically stopped by means of a solenoid which declutches the driving shaft and immediately applies a brake. After tripping in this way it is not possible for the slide to be set in motion again by power until the safety device has been completely restored to its normal condition.



Cam-operated switches *C1*, *C2* and *C3* operate at the end of cycle on press when tool is ascending in the following sequence :—*C1* closes, *C2* opens, *C3* closes, *C3* opens, *C2* closes, *C1* opens. Contacts made on amplifier relay when light ray is uninterrupted.

SIMPLIFIED DIAGRAM OF ELECTRONIC PRESS GUARD

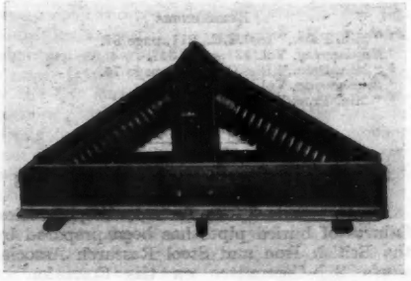
A schematic diagram of the guard is reproduced herewith. A low-voltage lamp energised from a transformer is employed as the light source and, to ensure reliability, the lamp is underrun so that the light output is mainly red. To avoid the photo-electric equipment being affected by stray light and changes in external lighting conditions the beam is modulated by means of a rotating disc mounted in the lamp house.

The output stage of the amplifier includes a relay with contacts which only close when the light beam is uninterrupted, and these contacts are used to operate a contactor which energises a solenoid operating the clutch and brake mechanism of the press. This solenoid is connected to the operating mechanism of the press in such a manner that the slide can only be set in motion when the solenoid is energised. The automatic check on the equipment is initiated by a cam mounted on the main shaft of the press, which is arranged to interrupt the beam momentarily towards the end of each cycle of operations and thus cause the relay in the amplifier to operate. This cam also operates a pair of contacts associated with the alarm relay and, provided the photo-electric relay has operated before the cam-operated contacts are made, the alarm relay does not operate; and when the light beam is restored the press is ready for the next operation. If, however, some fault is present in the photo cell or the amplifier, and the photo-electric relay fails to operate for any reason whatever when the light beam is interrupted, the cam-actuated contacts trip the alarm relay. Audible and visible warning of the fault is given by means of a klaxon horn and indicating lamp, and the press is stopped. The sequence of operation of the cam-operated contacts is detailed in the legend to the accompanying circuit diagram.

A Support Unit for Steam Pipe Lines

An interesting addition to the high-pressure, high-temperature pipework and range of ancillary equipment made by Aiton and Co., Ltd., of Derby, is a new pipe support. The development of this unit was started some time ago by the firm when it decided that with the ever-increasing working temperatures in steam pipe lines, and the consequent increase of thermal expansion in the pipes themselves, a support was needed which would adequately support the pipe, whatever position of the pipe unit at any time, due to the working temperature. It was decided at the same time to avoid, if possible, the use of the kind of support in which large movements of the pipe were accommodated by corresponding movements of a counterbalanced lever arm. This design of unit is not easy to fit in confined spaces, and it suffers from another disadvantage in that a long fulcrum arm is necessary to suspend relatively heavy weights.

The support eventually developed is known as the "Uniload," and is shown in the photo-graph reproduced above. In it two helical preloaded compression springs provide the lifting effort.



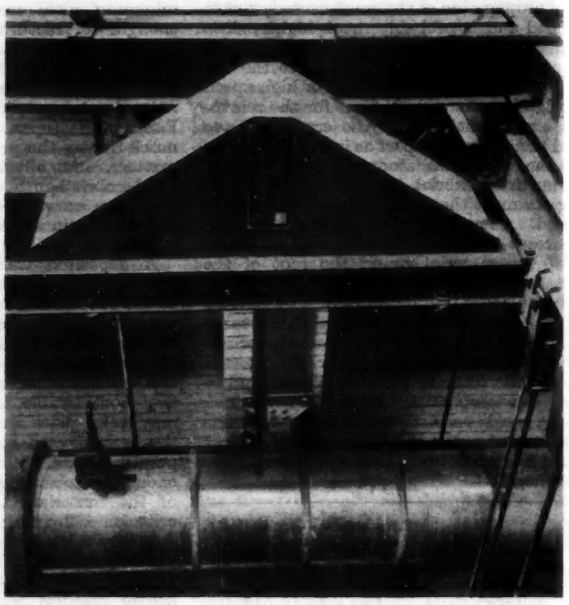
PIPE SUPPORT WITH COVER REMOVED

The "Uniload" support consists essentially of a rigid base, assembled from two angle sections, with foot plates for attachment to the pipe-supporting girders. In a triangular framework built up on the base, two opposed preloaded double helical springs are mounted. At their lower end, the springs are pivotally supported between the base members, and at the upper ends they are connected to a crosshead from which is suspended the pipe support rod. This crosshead, which moves up and down with the pipe against the load of the springs, slides between vertical guides and carries a pointer.

At present standard supports such as that illustrated are designed to carry loads from 10 cwt to 35 cwt, and they have a vertical movement of up to 6in. To meet special requirements individual units can be provided for any load or any amount of travel desired. One such unit recently supplied carries loads of 4½ tons throughout a vertical travel of 7½in.

Each support is preset at the maker's works before delivery for the designed load-carrying capacity and length of travel. In order that a unit can be correctly adjusted when installed, and its performance checked, a calibrated scale and pointer are fitted. The complete unit is enclosed in a light sheet steel housing, and the pointer spindle registers on a scale graduated in inches.

During erection of pipework supported by the units the crosshead remains in its uppermost position until the whole of the pipework has been connected up and lagged to reach the designed load. Then, in order that the position of the pointer can be correctly adjusted and the performance of the support indicated, the pointer is positioned by a turnscrew fitted on the pipe-support rod.



SUPPORT UNIT INSTALLED

Institution of Mining and Metallurgy

The Council of the Institution of Mining and Metallurgy has announced the election of Mr. Vernon Harbord, A.R.S.M., as president for the session 1952–53. He will take office at the Institution's annual meeting in May next. Mr. Harbord was educated at Tonbridge School, and, just prior to the first world war, entered King's College, Cambridge. On the outbreak of war, however, he was commissioned in the Royal Engineers, and served in France until wounded early in 1918. He was then seconded for duty with the Metallurgical Research Department at Woolwich. After the war, Mr. Harbord did not return to Cambridge, but went to the Royal School of Mines, where he obtained his A.R.S.M. in Metallurgy in 1920. He then spent a period of five years with the South Durham Steel and Iron Company, Ltd., first as metallurgist and technical assistant to the general manager of the Cargo Fleet works, and subsequently as general metallurgical adviser on the company's foundry work. Since 1926, Mr. Harbord has been a partner in the firm of Riley, Harbord and Law, consulting metallurgists, which was founded by his father, the late Mr. F. W. Harbord, and Mr. Edward Riley, in 1905.

"Iscor" Works at Vanderbijl Park

THE impending completion of the first installation of the plant and associated equipment described in this article inaugurates an era in South African engineering development when the inland metal industries of the country will become virtually independent of overseas resources. The initial output of the new works at Vanderbijl Park of the South African Iron and Steel Industrial Corporation, Ltd., is rated at 350,000 ingot tons per annum, which, together with the output at the Pretoria Works, is expected to bring the country's total output up to 1,000,000 tons per annum by the end of 1951. The new works lie about 10 miles west of Vereeniging, and, together with the surrounding area, the whole constitutes the growing realisation of its founder's dream that, even in an industrial milieu, the garden city ideal is not impossible of attainment. The decision to build the new Iscor Works in this area has led to important industrial developments there, including the erection of other works for a number of well-known and old-established engineering firms from overseas. These developments will be covered in a subsequent article.

Although the initial output of the new steel-melting plant is rated at 350,000 ingot tons per annum, the designs for future extensions make provision for an ultimate output of 1,000,000 ingot tons. Various sections of the new steel works have been put into operation during the past sixteen months, the coke ovens being in production as well as No. 1 blast-furnace and the hot strip mill. The first steel to be produced in South Africa by the new works was was delivered about eight months ago and was used by a Pretoria factory towards the end of November last for the manufacture of piping. A trial run was made with 10 tons of the steel, and executives of the factory later declared that it was of excellent quality and comparable in every way with imported strip.

Coke-Oven Plant

The coking plant is designed to have a carbonising capacity of 1290 metric tons per day of twenty-four hours, of wet coal, containing about 7 per cent moisture, blended in varying mixtures as received from the Transvaal and Natal coalfields. It comprises fifty-four W.D. Becker coke ovens built in two groups of twenty-seven ovens, divided by a central division wall and designed for heating with either coke-oven or blast-furnace gas. Included are two complete sets of oven machines, coal receiving bunkers with blending facilities, coke quenching station, coke cooling wharf, and coke handling and screening machinery.

The coal storage and handling plant comprises coal receiving bunkers of 5500 tons capacity with overhead oven bins, and coke screening and storage plant having capacities of 1151 and 2000 tons respectively.

By-Products Plant

A general view of the by-products plant is shown on page 282. As a necessary adjunct to the coke-oven plant it is designed for the recovery of concentrated ammonia liquor, benzole and allied spirits, naphthalene oils and tar. Primary cooling of the gas is effected by three vertical boiler-tube units, a fourth being included as a spare. The condensate from the primary coolers is divided as between the hot and cold ends of the units and collected separately, provision being made for the transferring of the condensate to compensate for loss or gain of liquor in the flushing system. As it leaves the primary coolers the gas passes through the exhausters—one being in operation and the other spare—after which it is pumped under pressure through two electro-detarrers, a naphthalene washer, three secondary gas coolers and two ammonia washers, then passing in series through two benzole scrubbers. A complete benzole recovery plant is provided for the production of crude benzole and its subsequent washing and rectification into motor spirit of various pure products. This will include three rectification stills.

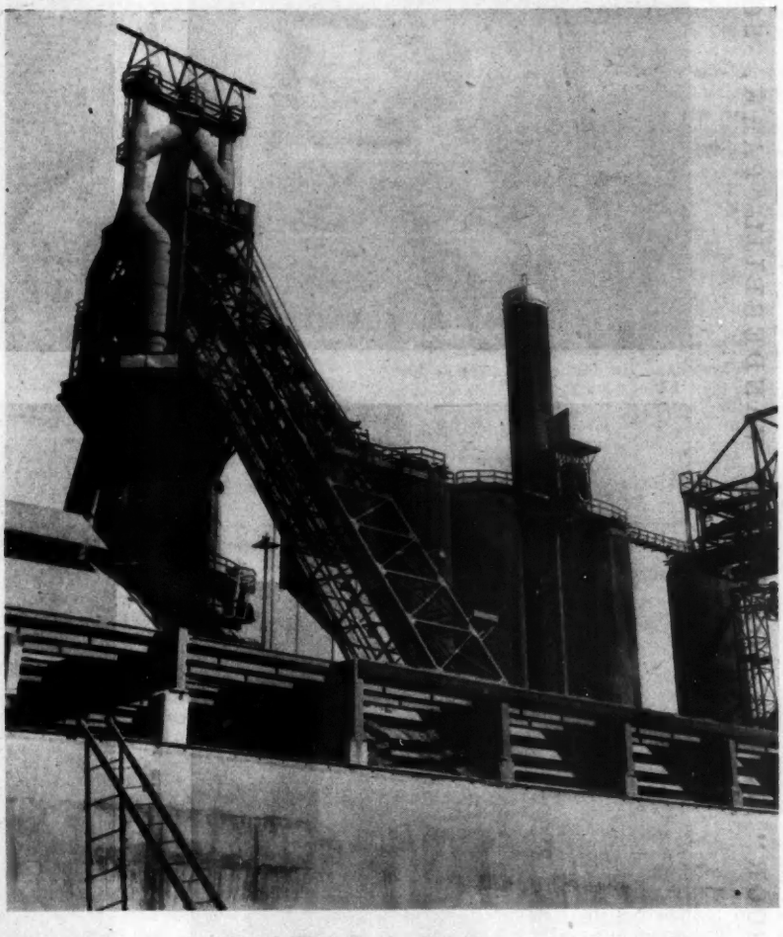
Tar distillation is a continuous process in a plant capable of dealing with 100 tons of crude tar per day, naphthalene oil crystallising equipment being included. The distillation plant furnace is designed to burn either pitch or coke-oven gas. The complete distillation plant deals with all the naphthalene oils and tar produced in the coke ovens and recovered in the by-products plant, distilling them into various fractions, including light oils, naphthalene, creosote, anthracene and pitch. The coke ovens, by-products recovery plant and tar distillation plant are so arranged as to cater for future extensions.

Included in the installation is a boiler plant for raising the steam required on the by-product and tar plants, and in various sections of the works. These boilers, besides being capable of burning coal or coke breeze or mixtures of them, is also arranged for burning coke-oven and blast-furnace gas. The plant, housed in its own building, and arranged for future extension, includes three water-tube boilers, each of 55,000 lb per hour normal capacity at 225 lb per square inch working pressure, the steam being superheated to 500 deg. Fah. The ancillary installations comprise fuel and ash handling equipment, together with water filtration and softening plant. Coke breeze handling plant for handling, screening and grading coke breeze returned from the coke screening equipment at the blast-furnaces, is also provided. This plant is designed to handle 15 tons of coke breeze per hour.

Blast-Furnace Plant

There are two identical blast-furnaces with full ancillary equipment, each having a hearth diameter of 21ft 6in, and each capable of producing 800 to 850 metric tons of pig iron per day of twenty-four hours. Future extensions are arranged for to include the installation of two more units. No. 1 blast-furnace is already in operation. A view of this blast-furnace, showing the skip and the hot blast stoves, is shown below.

The bin system has a capacity of 10,627 tons of ore and 620 tons of coke, providing a buffer store of raw materials between the stockyard and furnace demand, permitting adjustment of the mixture charged to the furnaces. The plant is complete with coke handling, screening and weighing equipment, and scale and transfer cars. The skip bridge receives charges of raw materials drawn from the bin system under control of the scale car operator and automatically delivers them to a mechanical distributor located at the furnace top.

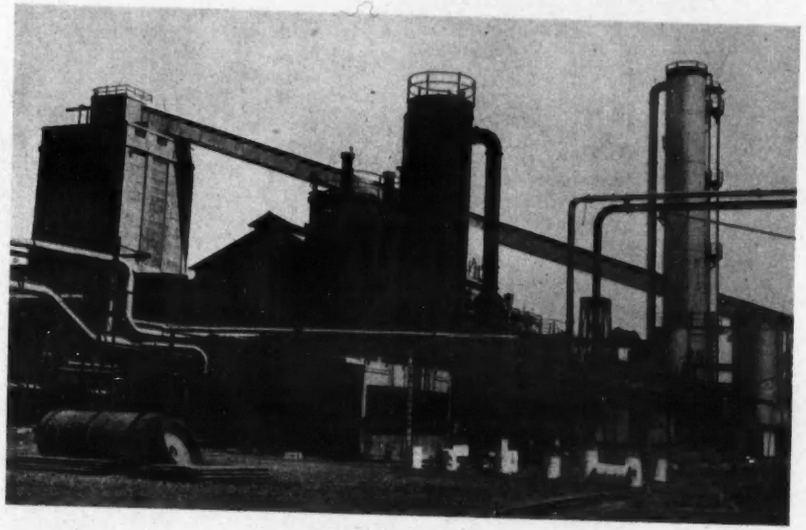


No. 1 Blast-Furnace

Other blast-furnace equipment includes stock line recorders, gas offtakes and dust catcher and a pug mill for consolidating the dust extracted from the gas. A 15-ton capacity travelling crane is installed in the cast house, together with hot metal and slag ladles with carriages. There are five hot blast stoves for providing the heat necessary in the air blast, complete with all service mains, gas burners and valves, space being provided for a sixth if required. The second blast-furnace with its ancillary equipment will go into production this year.

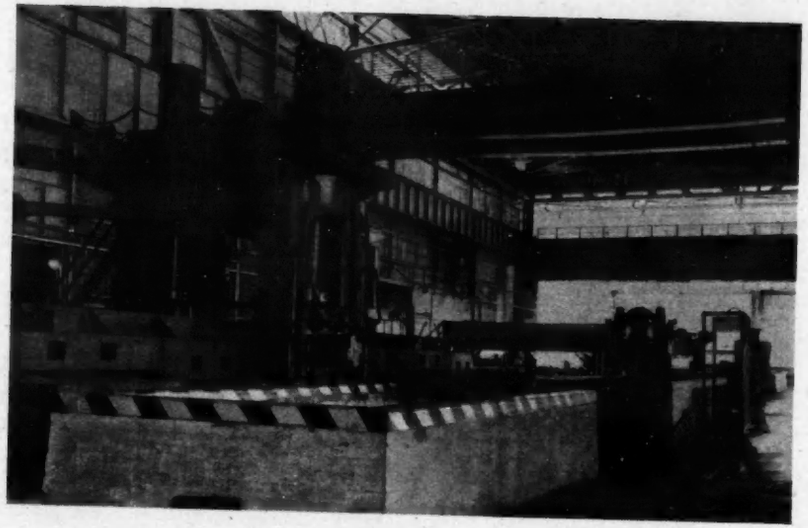
A double-strand pig-casting machine deals with hot metal at a continuous rate of 60 metric tons per hour on each strand, i.e.,

"ISCOR" STEELWORKS AT VANDERBIJL PARK, SOUTH AFRICA



BY-PRODUCTS PLANT

OPEN-HEARTH FURNACE



SLABBING MILL

HOT STRIP MILL

a total of 120 metric tons per hour, and the site can accommodate two such machines. The weight of the cast pigs can be varied up to 110 lb each. The air blowing equipment consists of three units, each capable of supplying the air requirements of one blast-furnace, each unit being driven by a 7000 h.p. synchronous motor. These units are so placed in the blower-house as to allow for the later addition of a pressure booster, and No. 2 blast-furnace has been designed in such a way that pressurised operation can be introduced if so desired. The blower house is provided with a 45/7½-ton travelling crane.

Gas cleaning plant of the single-stage wet electro-filter type has been installed to deal with the gas from two blast-furnaces and arranged for easy extension to serve more furnaces. The ore stockyard has a capacity of 255,000 metric tons, the stockyard walls being arranged to permit of further excavation to increase the capacity by 45,000 tons. As further blast-furnace units are installed, the walls can be extended. It will also provide storage space for sinter, when sintering plants are installed. An ore bridge is provided for stocking and reclaiming ore and other materials for the stockyard at a rate of 600 metric tons per hour, and this bridge will eventually serve four blast-furnace units and future sintering plants.

Steel Melting Plant

The steel melting plant has a rated capacity of 350,000 ingot tons per annum, and has been so designed as to permit a future increase in output to 1,000,000 ingot tons. An internal view of this plant, showing one of the open-hearth furnaces, is given opposite. A steel building provides accommodation for five fixed, open-hearth furnaces, each having a capacity of 160 tons per charge and provided with arrangements for gas or tar firing. Provision is made for two inactive (i.e. nonprocessing) hot metal mixers, service cranes and ancillary equipment such as ferrous ore crusher, dolomite throwing machine and ladle drying equipment, all arranged for easy extension to accommodate a total of ten open-hearth furnaces.

Two ladle cranes handle the ladles charging the open-hearth furnaces and hot metal furnaces and each has a charging capacity of 130/35 tons. Another two ladle cranes handle the casting ladles between the furnaces and the stations at which the metal is poured into ingot moulds. These travelling cranes will serve additional furnaces and mixers when installed. Other items of equipment in the melting house are four stationary jib cranes, one at each furnace, for handling hot metal spouts, each having a capacity of 7½ tons, and two travelling jib cranes of 2 tons capacity each for handling hot tops for capping ingot moulds. In addition, there are two floor travelling charging machines, each of 8½ tons capacity, for handling charging boxes containing various raw materials.

The one inactive (i.e., nonprocessing) hot metal mixer at present installed acts as a reservoir, having a capacity of 900 tons for receiving and storing hot metal delivered from the blast-furnaces at tapping times and supplying the varying demands of the open-hearth furnaces. The mixer is arranged for coke-oven gas firing. For heating the open-hearth furnaces, eight gas producer units have been installed complete with coal storage and handling arrangements for coal and ash.

Four waste heat boilers with ancillary equipment, one for each furnace, have been provided for recovery of heat from the open-hearth furnace waste flue exit gases, and raising steam at 250 lb per square inch, the steam being superheated to 500 deg. Fah. The steam yield per boiler is dependent upon the quantity, weight of and heat contained in the exit gases. This yield varies between 11,600 lb and 25,500 lb per hour.

A fuel tar plant provides auxiliary heating for the open-hearth furnaces with storage, pipelines and burners. General storage facilities include a mould yard served by two 20-ton cranes for storage and preparation of ingot moulds, a brick shed for storage and preparation of refractory materials housing two jaw crushers and two pug mills, a scrap yard equipped with two 15-ton cranes for storage and preparation of scrap metal for furnace charging, and a raw materials bunker and ramp arranged to receive incoming raw materials. The last-mentioned provides storage for 300 metric tons of dolomite, 900 tons of lime, 1700 tons of limestone and 1400 tons of ore.

A skull cracker yard and slag yard is provided where slag and skulls from the melting shop are broken down into sizes suitable for the charging boxes, and is served by a travelling crane of 50/15 tons capacity. The steel melting building is also served by two 200/30-ton stripper cranes for the removal of ingot moulds before the ingots are passed on to the soaking pits. These cranes have a hoisting capacity of 30 metric tons and a stripping pressure capacity of 200 metric tons.

Rolling Mill Plant

The initial output of saleable products originally contemplated, including that of the existing plate mill, was approximately 240,000 metric tons per annum, including steel plates of ¼in and upwards (70,000 tons), uncoated sheets (20,000 tons), galvanised sheets (100,000 tons), tube strip or skelp (20,000 tons), and tinplate (30,000 tons). Steps have been taken to increase by a substantial amount the output of plates, and an increased output of tinplate is being investigated.

The rolling mill plant comprises six soaking pits with full ancillary equipment for the soaking of hot and/or cold ingots. The pits are suitable for firing by means of mixed coke-oven and blast-furnace gas and are served by two 15-ton travelling cranes. This initial installation is capable of handling the rated output of 350,000 ingot tons per annum and is arranged for future extensions.

The Slabbing Mill.—The slabbing-blooming mill plant consists of one 46in two-high reversing slabbing-blooming mill and ancillary equipment, having working rolls 43in in diameter by 100in body. A view of the slabbing mill is shown opposite. The plant is capable of producing slabs up to 54in maximum width and 10in maximum thickness with maximum weight of slabs of 30,000 lb, and also billets down to 6in by 6in from ingots weighing 10,000 lb. The main mill motor has an r.m.s. rating of 7300 h.p. and a peak rating of 23,000 h.p. The Ilgner set is driven by a 5000 h.p. motor and the plant is served by one travelling crane of 75/20-ton capacity, and, in the motor room, one travelling crane of 50-ton capacity. There is a slab yard for storing slabs and billets, which is served by two 25/10-ton cranes as well as one scarfing crane suitable for manipulating slabs up to 30,000 lb weight.

A slab reheating furnace, with ancillary equipment, has been installed. It has a capacity of 100 tons per hour and is arranged for firing by means of a ternary mixture of producer, blast-furnace and coke-oven gas. The furnace is designed to handle slabs up to 8ft long in two independent rows, or slabs up to 16ft in one row.

The existing plate mill, which has been in operation since 1943 (using slabs from Pretoria) consists of one 38in and 52in by 110in four-high reversing plate mill unit with a slab reheating furnace and ancillary equipment for the rolling of sheared plates, ⅛in to 1½in thick of 96in maximum width and 30ft maximum length, from reheated slabs, at the rate of 300 metric tons per eight-hour shift. The plant is also capable of rolling ¼in plate in narrower width and shorter lengths. Now the mill will also roll slabs to suitable dimensions as input material for the new hot strip mill. A vertical edging mill is being installed in the approach table before the plate mill, and also a plate centring apparatus for the end shear approach table. An improved furnace bumper is being fitted to the slab reheating furnace.

The Hot Strip Mill.—This mill comprises six 22½in and 45in by 56in four-high stands and ancillary equipment. Stands Nos. 1, 2, 3, 4 and 5 are driven by 3500 h.p. motors, and No. 6 by a 3000 h.p. motor. Two motor generator sets each driven by a 10,000 h.p. synchronous motor supply the direct current for the mill motors. The hot strip mill plant produces, from input material received from the reversing plate mill, coils of strip steel as follows :—

Thickness	Maximum width
0·0785in and heavier	50in
0·0625in and heavier	48in
0·0490in and heavier	38in

The plant is served by one 15-ton and one 25/10-ton travelling cranes. A view of the hot strip mill is shown on the opposite page.

A continuous pickling plant is provided for pickling hot rolled steel strip 18in to 50in wide up to ⅛in thick, and is served by a 15-ton travelling crane. There is also a batch pickling machine of the four-arm, steam-operated, air-balanced type for pickling batches of sheets and tinplate gauge material in cradles. An acid neutralisation plant has been installed, designed to neutralise effluent liquors from the batch pickling and cleaning lines, and also a pickle liquor concentrating plant for dealing with spent pickle liquor (an aqueous solution of sulphuric acid and ferrous sulphate), discharged from the continuous pickling line, and for removal of ferrous sulphate precipitated from the concentrated pickle liquor in a form suitable for use in the manufacture of sulphuric acid.

The Cold Mill.—This includes one 19in and 52in by 56in four-high, four-stand tandem cold mill and ancillary equipment. The stands are driven by 1500, 2500 and 3000 h.p. motors respectively, being supplied with direct current from one motor generator set driven by a synchronous motor of 11,600 h.p. There are also one 19in by 56in four-high, single-stand, skin-pass mill and equipment for coils only, and one 28in by 55in two-high, single-stand, skin-pass mill and ancillary equipment for hot and cold rolled sheets 50in wide up to 20ft long. The main and tension reel motors for these two mills are each of 500 h.p. Arrangements have been made for the future installation of machinery which will handle coils.

Coils and sheets of cold rolled strip steel are produced from hot rolled pickled coils in the form of tinplate gauges down to 0·0075in and sheet gauges in the range from 0·105in to 0·012in. The cold mill plant will be served by two 15-ton, one 25-ton and one 50/20-ton travelling cranes. A strip cleaning line has been installed to remove rolling oil from cold reduced strip; it is arranged for future conversion to electrolytic cleaning. There are two continuous galvanising lines suitable for the normalising and galvanising of steel strip coils of 0·0490in to 0·0123in up to 48in wide. These lines each have a maximum output of 27,000 lb per hour and are served by two 15-ton travelling cranes. A 58in conventional sheet galvanising line will handle cut-to-length sheets up to 48in wide by 64in to 244in long, and 0·0625in thick or heavier.

Annealing furnaces in this division are suitable for tinplate coils up to 48in O.D., and sheets in coil or flat form. These furnaces are arranged for coke-oven gas firing and have a capacity of 70,000 tons per annum in the form of coils for tinplate and sheet in coil and flat form. The annealing plant is served by one 50/20-ton travelling crane.

Four hot-dip tinning units have been installed including electrolytic pickling units and full ancillary equipment suitable for the production of commercial tinplate. They can handle 0·0196in to 0·0048in tinplate in sizes from 30in maximum width and 36in maximum length, the rated capacity being 30,000 tons per annum. The plant is served by two 15-ton travelling cranes for dispatching and one 10-ton crane for maintenance purposes.

Essential Services

Steam, Compressed Air and Electric Distribution.—The installation of essential services required has kept an army of workers busy for several months providing the wherewithal for the production and distribution of steam and compressed air for operating purposes throughout the works. There are seven 11kV substations serving the works, all

connected on to a ring main system. Secondary distribution voltages are 3·3kV and 380V a.c., and 440V d.c. Pumpless steel bulb rectifiers are used to obtain the d.c. supply. The electric power is supplied by the Electricity Supply Commission, Rand Undertaking, through two lines each carrying current at 80kV to the main substation where the current is transformed to 11kV.

Maintenance Shop and Stores.—The workshops include accommodation for a boiler shop, locomotive shop and electrical maintenance shop with provision for extensions, the whole being served by two 10-ton and one 25-ton cranes. The stores include plant stores, served by two 10-ton cranes, general stores, rebate stores and oil stores.

Gas Holders and Distribution.—The production and consumption of gas are both irregular and intermittent, thus rendering it necessary to provide storage to meet peak demands. This is provided by gas holders for 1,000,000 cubic feet of coke-oven gas, and 2,000,000 cubic feet of blast-furnace gas, the gases being cooled and cleaned before storage. Distribution to the various points of consumption is regulated from a central control station.

Water System.—The plant has a capacity of 5,000,000 gallons of river water per day, and all incoming water from the Vaal River is treated for the removal of suspended solids and reduction of the pH value. A riverside pumping station delivers water to a 50,000-gallon low-level reservoir and a 5,000,000-gallon reservoir. The main pumping plant for dealing with the water requirements of the blast-furnace and melting shop plant include two Mouchel water-cooling towers. The service water pumping plant which deals with the water requirements of the rolling mills, includes clarifiers for the removal of mill scale and a Mouchel water-cooling tower.

Rail Tracks, Roads, Weighbridges and Locomotives.—This section covers all transport ways and fencing throughout the works, including marshalling yards and the weighbridges dealing with incoming raw materials, hot metal in process and finished products. For the existing plate mill services and construction requirements, steam locomotives are in operation. These will gradually be replaced by diesel-electric locomotives, of which there will be nine 35-tonners (275 h.p.) and six 65-tonners (550 h.p.). Railway wagons are being obtained to meet internal traffic requirements. One diesel-engined, flameproof locomotive is provided for shunting operations about the coke-ovens by-products plant, while a second locomotive will be used on the operating platform of the open-hearth furnaces.

American Engineering News

(From our American Correspondent)

Mechanical Properties of Metals at Low Temperatures

A symposium on the mechanical properties of metals at low temperatures was held recently at the National Bureau of Standards in Washington, D.C., under the joint chairmanship of T. G. Digges and G. A. Ellinger, of the Metallurgy Division of the Bureau. The opening paper, "Mechanical Properties of High-Purity Iron-Carbon Alloys at Low Temperatures," by R. L. Smith, Professor G. A. Moore, and Professor R. M. Brick, of the University of Pennsylvania, summarised the effects of carbon content within the range of 0·05 to 0·5 per cent of carbon, at temperatures from —185 deg. Cent. to room temperature, on tensile properties and on natural stress-strain curves. It was shown that increases in carbon content resulted in increases in stresses at yield points, in flow stresses at constant strain and constant temperature and in fracture stresses. Decreases were observed in total strain at fracture. The transition temperature, based on the energy required to fracture tensile specimens, was found to be about —160 deg. Cent. to —170 deg. Cent. and to be independent of the carbon content within the above range. A paper, "Brittle Fracture in Ship Plates," presented by Dr. M. L. Williams, of the National Bureau of Standards, showed that, although failures had been reduced by improvement in design details and welding workmanship, many plate failures were traceable to the quality of steel, especially with respect to the notch sensitivity as measured by the 15ft-lb transition temperature in Charpy V-notch tests. Notch sensitivity was found to increase with increased carbon, phosphorus, molybdenum, or arsenic content and grain size and to decrease with increases in silicon, manganese, copper, or nickel content. The combined effects of these elements were shown not to be simply additive.

Dr. N. P. Allen, of the National Physical Laboratory, in a paper entitled "Recent European Work on the Mechanical Properties of Metals at Low Temperatures," gave an account of European research since 1940, including the effect of low temperatures on the following:—Behaviour of common engineering metals and alloys, elastic constants, mechanisms of slip, brittle fractures of ferritic alloy steels as affected by alloy content, heat-treatment, and similar variables. Special attention was given by Dr. Allen to work at the National Physical Laboratory on the effect of carbon, oxygen, manganese, and combinations of these elements on the low-temperature properties of high-purity iron (99·96 per cent Fe). A discussion of "The Manufacture of Steels for Low-Temperature Service," by Dr. J. B. Austin, of the United States Steel Company, pointed out many of the salient factors necessary for the production and processing of steels suitable for low-temperature service. Among these were fine grain size, suitable microstructure in ferritic steels, a tempered martensitic structure of desired hardness level, complete deoxidation of steel, preferably with aluminium, and addition of certain alloying elements. The choice and amount of the beneficial alloying elements, however, depends upon precise service conditions and economic factors.

A paper on "The Development and Application of Chromium-Copper-Nickel Steel for Low-Temperature Service," by W. Crafts and C. M. Offenhauer, of the Union Carbide and Carbon Research Laboratories, presented data showing how a normalised low-alloy steel suitable for low-temperature service down to —100 deg. Cent. was developed by addition of approximately ½ per cent each of manganese, copper, nickel, and chromium. Emphasis was placed on the beneficial effect of deoxidation with aluminium to assure a fine grain size. It was found that increasing the residual aluminium content to approximately 0·2 per cent gives an additional improvement, thus producing a steel suitable for use at slightly lower temperatures. A study of "The Properties of Austenitic Stainless Steels at Low Temperatures" was given by Dr. V. N. Krivobok, of the International Nickel Company. Data on the effect of low temperatures on the modulus of elasticity, ductility, fatigue impact, tensile impact, tension, and other mechanical properties were summarised. The effect of cold working at low temperatures and the beneficial effect of low temperatures on ductility characteristics were discussed in detail. The beneficial influence of the low carbon content of these alloy steels on their mechanical properties at low temperatures was also described.

A paper on "The Application of Metals in Aircraft at Low Temperatures," by J. B. Johnson and D. A. Shinn, of the Wright-Patterson Air Force Base, discussed briefly the relationship of the properties of metals as determined by conventional laboratory tests and those selected by the designer. Data on tests of aircraft metals at temperatures down to —420 deg. Fah. were presented. Professors C. W. MacGregor and N. Grossman, of the Massachusetts Institute of Technology, in their paper on "Dimensional Effects in Fracture," discussed the influence of specimen size and the effect of various ratios of combined stresses on the transition temperature from ductile to brittle fracture. Slow bend tests at various temperatures with flat circular discs of 0·95 per cent carbon steel simply supported around the circumference and loaded by a force at the centre indicated that the size effect in ratio ranges of 6 to 1 was insignificant when similarity of specimens and test conditions was maintained. Other experimental data indicated that the transition temperature of this steel increased about 60 deg. Fah. as the biaxial stress ratio was varied from 0·483 to 1·0. The closing paper, "Tensile Properties of Copper, Nickel, and Some Copper-Nickel Alloys at Low Temperatures," by G. W. Geil and N. L. Carwile, of the National Bureau of Standards, discussed the results of tension tests made at temperatures ranging from +110 deg. Cent. to —196 deg. Cent. Graphs of true stress versus strain did not exhibit the commonly accepted parabolic relationship. The initial and ultimate strengths and the true stresses at maximum load and at initial fracture were shown to increase continuously with decrease in temperature. The true strain at maximum load increased slightly with decrease in temperature, but no significant change in the strain at fracture was observed. The rates of work hardening at specific true strains, in general, increased with decrease in temperature and, in the case of the alloys, were affected greatly by their compositions.

Water Seepage into Brooklyn-Battery Tunnel

An unusual and unexpected maintenance operation has become necessary at the Brooklyn-Battery tunnel in New York City, which was opened to traffic just over a year ago. Although the tunnel is considered fundamentally sound and will grow sounder as it ages and as salt crystallises in the small openings near the seams of the cast iron and concrete lining, workmen are now removing 1400 lb of highly corrosive salts and inert matter each week. This accumulation is due mainly to the speed of the air circulating through the tubes. Blowers and exhaust fans provide a normal maximum ventilation of 4,161,000 cubic feet of fresh air a minute. The rush of air causes much of the water to evaporate and the residual matter thus tends to clog the drains. Special fittings were designed to siphon the flow to the pumps under the road bed which lead the excess water back into the river. Drains were enlarged and galvanised pans were set in place. The task of controlling the seepage is out of sight of the 40,000 motorists who now travel daily through this longest underwater crossing in the United States. The trouble points are in the exhaust ducts over the road bed. The designers of the tunnel were confident that it would be a "dry" tunnel for the most part. When it was opened it had gutters only in a small section under the river bed between the ventilation building on Governors Island and the Manhattan shore. It was not until owners of convertible automobiles started to complain that they were being hit by drops of water or that the canvas coverings of their cars were being ruined by the seepage that the Triborough Bridge and Tunnel Authority took action. The deteriorating effects of the steady leaks can now be seen clearly on the inner, flat-tile roof of the tubes. At the lowest part of the tunnel, 115ft below the surface of the river, some of the white tiles are badly discoloured, there are chinks in others, and at the joints large patches of salt crystals stand out. In the duct chambers water still spills occasionally through the ventilating louvres, but as quickly as a leak is discovered more pans are being installed. The Authority is experimenting to determine the best method of waterproofing the concrete lining and the gutter beds so that the lime and sandstone will not work loose. So far, it has not found a satisfactory process. The men clearing the gutters, in which 5 lb of salt and solids collect every 30ft, break the monotony of the job by competing to discover the most interesting stalactite formations. The Brooklyn Battery Tunnel was described in "The Engineer" of Sept. 8th and 15th 1950.

OIL CONSULTANT SERVICE.—Entitled "Petrocarbon Services," Petrocarbon Ltd., of Manchester, have issued a new booklet which gives in brief outline the worldwide services offered by the company in the design, development and building of oil refineries and plant for the production of chemicals from oil and other materials.

Industrial and Labour Notes

British Overseas Trade

The final figures of United Kingdom trade in July, which were published at the end of last week, give the value of exports as £222,200,000, compared with the low June total of £200,000,000. The July figure, the Board of Trade says, was equal to the average for the second quarter and 7 per cent above the average for the first half of this year. It is acknowledged that a further increase in export prices accounted for the higher value of exports in July, but the volume of exports was greater than in June, the index for July being estimated provisionally at 170 (1947=100), compared with 173 in the second quarter and 160 in the first quarter of this year.

More than half the increase in exports in July, compared with June, was in metal goods and engineering products. The value of these totalled £104,500,000 in July, which was £13,000,000 above the June figure and 9 per cent above the average for the first half-year. Whilst a Board of Trade survey shows that all groups of exports were greater than in June, the main part of the rise above the average for the first half of the year was due to the higher value of exports of machinery, vehicles and electrical goods. The number of cars and chassis exported in July—28,872, valued at £9,500,000—was much the same as in June, a sharp fall in deliveries to Canada being offset by larger figures for some other markets, principally New Zealand, Australia, Eire, Sweden and Brazil. July exports of agricultural tractors numbered 10,208, valued at £4,000,000.

The index numbers of import and export prices (average for 1950=100) shows that, in July, export prices rose by two points to 122, and that import prices fell by one point to 142.

Woodworking Machinery Productivity Team

The Anglo-American Council on Productivity has announced the departure for the U.S.A. this week of a specialist team drawn from the British woodworking machinery industry. It is the fiftieth productivity team, representative of British industry, to visit the U.S.A. under the auspices of the Council. The woodworking machinery team is led by Mr. F. W. Burrows, a director of John Sagar and Co., Ltd., and its membership includes representatives of the supervisory, technical and operative grades. The members of the team will spend six weeks in America, during which time they will visit the principal centres of production of woodworking machinery. It is stated that arrangements are now in hand for the visit of the present team to be followed by one of a specialist team from the metal-working machinery industry.

The Coal Situation

The saleable output of deep-mined coal last week amounted to 3,987,600 tons—compared with 3,845,200 tons in the corresponding week of last year—and, with 244,300 tons obtained from opencast workings, gave a total production for the week of 4,231,900 tons. The Ministry of Fuel and Power estimates that recognised holidays last week caused a loss of 134,700 tons of deep-mined coal, and disputes a loss of 11,100 tons. In the first thirty-four completed weeks of this year, the total amount of coal raised was 142,430,500 tons, compared with 139,489,500 tons in the corresponding weeks of last year.

Sir Hubert Houldsworth, K.C., the newly appointed chairman of the National Coal Board, has this week asked for "more rapid progress" in coal production in this country. Speaking at the opening of the Coal Board's summer school at Oxford on Monday last, he recalled that, in 1946, the output of saleable coal from the deep mines was 181,000,000 tons, the output per manshift at the face being 55·2 cwt. By 1950, Sir Hubert said, the saleable output had increased to 204,000,000 tons, and the output per manshift at the face to 62·2 cwt. That, he agreed, showed progress, but, he pointed out, it had not met the national need for coal, and the prevailing needs and circumstances demanded that more rapid progress should be made.

Sir Hubert went on to say that, in addition to inventive genius and technical skill, the ready co-operation of all grades of workers at the pits was essential to success. There must be a ready acceptance of change, of new machines and methods, and a determination to make them work with the maximum efficiency. The response to the Prime Minister's appeal in the early months of this year, Sir Hubert claimed, was magnificent, but, he urged, the country needed a similar response in the remaining months of this year. The maximum degree of Saturday working, he observed, could give the immediate increase in coal output which was so necessary. The recent downward trend in manpower Sir Hubert described as disturbing. Recruitment, he urged, must be stimulated, wastage must be diminished, and if minor accidents could be reduced substantially much loss of time would be avoided. The available manpower, he emphasised, must be used to the best advantage, and the deployment of manpower should be examined at regular and frequent intervals at every pit.

Railway Wages

The three railway unions — the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs' Association—last week submitted to the Railway Executive statements in support of their joint claim for a 10 per cent wage increase. The unions also presented the claim last week to the London Transport Executive.

At a meeting of the employee's side of the Railway Shopmen's National Council, held on Wednesday of last week, it was agreed that a claim for an "immediate and substantial" wage increase should be advanced on behalf of workers in railway engineering shops.

Iron and Steel Scrap Prices

The Minister of Supply has made the Iron and Steel Scrap (No. 4) Order, 1951, by which the controlled maximum prices of iron and steel scrap have been increased from August 27th. The increase is £2 a ton, except for compressed destructor scrap and two lower grades of unprepared process scrap, the increase for which is £1 10s. a ton.

The Ministry of Supply says that, apart from small increases mainly to meet additional transport costs, prices of delivered iron and steel scrap have been kept stable since 1937. The maximum prices for iron and steel scrap, other than alloy steel, have ranged from £2 1s. 5d. to £9 9s. 4d. a ton, but in the main they have not exceeded £5 a ton. Recently, there have been indications that the low prices were beginning to affect the volume of scrap flowing back to the iron and steel furnaces. The purpose of the higher prices, therefore, is to stimulate the collection of ferrous scrap. This, the Ministry emphasises again, is an urgent need in view of the decline in the supplies of imported scrap and the great importance of increasing steel production. A small part of the increased price is needed to defray increased costs of collection, processing and handling, particularly in the case of the smaller merchants and in the more remote areas. Apart from that, however, the Scrap Merchants' Federation has given an assurance that the increase will be passed on to the owners of scrap to encourage them to return as much as possible. The scrap merchants have also assured the Ministry that the rise in prices will secure a substantial increase in the recovery of scrap.

The Ministry of Supply has also announced that, with the exception of two special grades of iron, the controlled prices of iron and steel are not being increased to consuming industries. Some adjustments, however, are necessary, within the steel industry itself, in the prices of semi-finished steel, and to give them effect the Iron and Steel Prices (No. 3) Order, 1951, has been made. It came into operation on August 27th, and provides for price increases per ton as follows:—Cylinder and refined iron, 25s.; cold blast pig iron, 15s.; semi-finished steel: billets, 5s.; sheet and tinplate bars, 7s. 6d.; forging ingots, 25s.

The Steel Industry's Rising Costs

In the latest issue of its *Monthly Statistical Bulletin*, the British Iron and Steel Federation has made some comments on the increased prices of steel which came into operation on August 13th. It points out that these increases followed a period of price stability in the British steel industry which had lasted almost two and a half years, the last general advance in steel prices having been made on April 1, 1949. The cost increases during that period of price stability have been borne by the industry itself, a burden which has been eased by the industry's improvements in efficiency. Until recently, the main cost items to be faced were the advance of one-sixth in rail freight rates in May, 1950, the gradual rise in wages, and the increased cost of imported materials, including oil.

The *Bulletin* explains that, over the past year, the main increase has been in the cost of imported materials, due partly to the delayed effects of devaluation, but more particularly to the repercussions of the war in Korea. Though imported materials normally account for less than a quarter of total steel-making costs, they have about doubled in the last twelve months, and the effect on the steel industry's finances has thus been very considerable. The cost of bringing imported ore to this country from the North African port of Bona, for example, rose from 21s. a ton in June, 1950, to 28s. 6d. by the end of last year, and to 61s. by June, 1951—a total increase of 190 per cent. As the British steel industry has vessels on charter, the advance in freight rates on the open market is not yet fully in its shipping costs. Nevertheless, the Federation says, the average c.i.f. price of imported ore had risen by nearly 60 per cent—from 57s. to about 90s. a ton—over the twelve months to June, 1951, and the f.o.b. ore prices included in that figure are still mainly the 1950 contract prices.

In the same period—the twelve months ended June, 1951—imported pig iron has gone up in price from £13 9s. to £18 5s. a ton. Imported scrap jumped from an average of £8 13s. a ton c.i.f. in the second quarter of 1950 to £12 2s. in the first quarter of this year, and is now over £16 a ton. Similarly, the industry was paying £15 5s. a ton for Continental billets in the third quarter of last year and is now paying £36 5s. a ton. In round figures, in fact, the Federation states, the extra cost of imported raw materials, including pig iron and semi-finished steel, represents 40 per cent of the total increase to be covered by the price advance.

The *Bulletin* adds that the extent to which the higher cost of imports can be offset by an increased use of home-bought materials is small. The main possibility lies in the limited substitution of home for foreign ore. But that can be done only on a restricted scale, because it reduces blast-furnace capacity and thus results in a loss of steel production, and also involves an increased coke consumption per ton of pig iron.

Notes and Memoranda

Rail and Road

"South Wales Roads."—The most recent publication of the British Road Federation is entitled "South Wales Roads," and is intended to draw attention to the deplorable state of the roads in South Wales, and of those which link South Wales with the industrial areas of the Midlands. The Ministry of Transport's plans for the area are described, and the urgent necessity for carrying them out, in view of recent industrial developments in South Wales, is explained in the booklet.

New Containers for British Railways.—One thousand 4-ton fabricated steel containers, made to a new design and intended for conveying ground limestone, dolomite, fluorspar, alumina, cement and similar substances have been ordered by British Railways. The new design has been based upon the result of experiments made with a prototype. The container is in the form of a lidded box divided into two equal compartments, which can be discharged simultaneously or separately through bottom doors. The doors open by gravity on release of a simple hand lever-operated catch, and the lid requires a minimum of headroom when open. Cleats are provided on the sides of the container so that sheets may be fixed during unloading to keep down dust. A contract for the construction of the containers has been placed with Cravens Railway Carriage and Wagon Company, Ltd., of Sheffield.

Air and Water

Mechanical Seals.—The oil tanker fleet operated by the Esso Transportation Company, Ltd., are to have "Flexibox" mechanical seals fitted to their cargo oil pumps. They are of centrifugal design, horizontally split with stuffing-boxes at either side operating at 1750 r.p.m. and temperatures up to 140 deg. Fah., the delivery pressure being 125 lb per square inch gauge.

Operations of Civil Jet Aircraft.—A conference of representatives of all Commonwealth, including Colonial, Governments will be held from September 25, 1951, to October 5, 1951, at the Royal Empire Society Hall, Northumberland Avenue, London, W.C.2, to examine the problems of air traffic control arising from the introduction of turbo-prop and turbo-jet aircraft on the Commonwealth routes; to discuss matters of ground organisation and to consider other general technical matters. The conference will be under the chairmanship of Air Chief Marshal Sir Frederick W. Bowhill, Chief Aeronautical Adviser to the Minister of Civil Aviation.

Liquid Gas Barges.—There is an extensive market for liquid petroleum gas, as a domestic and industrial fuel, in Belgium, and the excellent waterways in Holland and Belgium make it possible to use water transport, which is more economical than road or rail. To carry the "Butagaz" two barges named "Butania I" and "Butania II" have been built, each having a length of 150ft, a breadth of 20ft, a depth of 9ft and being driven by a two-stroke, four-cylinder, Bolnes diesel engine developing 200 b.h.p. at 428 r.p.m. Each vessel has a capacity of 128 metric tons and is fitted with two horizontal tanks, 40ft long by 12ft diameter, having a working pressure of 100 lb per square inch. Carrying a crew of three, the barges make the round trip from the Shell refinery at Pernis, in Holland, to Ghent and Brussels, in three days.

Miscellanea

Commonwealth Scholarships.—The first two students awarded scholarships under the Brush ABOE Commonwealth Scholarship Scheme for engineering graduates have arrived in Britain, one coming from New Zealand and the other from India.

Commercial Conditions in Pakistan.—A survey of economic and commercial conditions in Pakistan has been published by H.M. Stationery Office, price 5s. It is the latest volume in the series of overseas economic surveys issued by the Commercial Relations and Exports Department of the Board of Trade.

"The Condenser Cone."—An informative booklet, entitled "The Condenser Cone," published by Standard Telephones and Cables, Ltd., has now reached its second edition. It explains the principles and applications of the condenser cone, and it includes sufficient design data to assist in the choice of a cone, its length, and the diameter of the metal former. Some worked examples are given and there are notes on cones used with guard rings in Schering bridge measurements, and their use in conjunction with line protection relays, and as high-voltage capacitors.

Swedish Steel Industry's Expansion.—It is stated that the Swedish iron and steel industry is carrying out a large extension and modernisation programme. It is estimated that by 1955 the productive capacity of the industry will be increased to over 2,000,000 ingot tons of steel a year, compared with the present annual production of about 1,400,000 tons.

Gas Burning Radial Engines.—The first of eighty gas-burning radial engines ordered from the Nordberg Manufacturing Company, of Milwaukee, Wisconsin, has been delivered to the new Kaiser aluminium reduction plant at Chalmette, Louisiana. The engine is of two-cycle design, and has eleven cylinders of 14in bore by 16in stroke. It develops 1920 h.p. at 400 r.p.m. and will drive a 1290kW d.c. generator.

Lecture Course in Structural Analysis.—The Yorkshire Association of the Institution of Civil Engineers intends to give a course of lectures on advanced structural analysis, starting in October and continuing until March, 1952, and consisting of twenty-four periods at the University of Leeds. Further details of the course may be obtained from the Assistant to the Director, Department of Extra-Mural Studies, The University, Leeds, 2.

Instrument Training Courses.—In response to increased demands for instruction, Elliott Brothers (London), Ltd., has started regular training courses at its head office, Lewisham, in instrument maintenance and repair, for the benefit of instrument users. Each course lasts three weeks, and there are no fees. Particulars of the courses are obtainable from the Service Training Department, Elliott Brothers (London), Ltd., Century Works, Lewisham, London, S.E.13.

Electrical Engineers' Exhibition.—At the annual conference of the Association of Supervising Electrical Engineers it was decided to organise, on a national scale, an electrical exhibition in London. The exhibition will be held at the New Hall, The Royal Horticultural Hall, Westminster, on March 28 and 29, 1952. Electrical manufacturers are invited to exhibit, and further particulars can be obtained from Mr. P. A. Thorogood, 35, Gibbs Green, Edgware, Middlesex.

"The Design of Welds."—A brochure entitled "The Design of Welds" has been published by the construction design department of the Quasi Arc Company, Ltd., Bilston, Staffs. With its recently issued companion brochure, "Welded Roof Trusses," the new publication forms the start of a series of booklets on the design of welded structures and is intended to meet the needs of designers and draughtsmen who have been trained in the conventional riveting methods.

"Mastery of Measurement."—The booklet "Mastery of Measurement," recently published by Marconi Instruments, Ltd., St. Albans, Herts, is something more than a mere catalogue of some of the electronic instruments manufactured by the company. It is a well-illustrated handbook containing concise descriptions of a selection of Marconi instruments under the following headings:—Measurement of voltage, power, and frequency; bridges and Q meters; oscillators; signal generators; transmission measurement, television and radar measurement; industrial instruments; and electro-medical apparatus.

Development Areas Advisory Committee.—The Treasury announces that Mr. T. H. Summerson has been appointed an additional member of the Development Areas Treasury Advisory Committee. Mr. Summerson, who is an immediate past-president of the Teesside and West Durham Chamber of Commerce, has special experience in relation to industry in the North-Eastern Development Area. He is chairman and joint managing director of Thomas Summerson and Sons, Ltd., and Summerson Foundries, Ltd., chairman of Copelaw Engineering Company, Ltd., Print for Industry, Ltd., Seamer Hill Farms, Ltd., and Wear Fans, Ltd., and a director of R. Summerson and Co., Ltd.

"Osram" Valve Manual: Part I.—The fifth edition of the "Osram" Valve Manual, Part I, recently published (price 5s.) by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, gives details of the company's radio receiving valves, cathode ray tubes and electronic devices, including Geiger Muller tubes, gas-filled arrestors and silicon and germanium diodes. The information given includes full characteristics, operating data and curves. There is a brief introductory section outlining the history of valve development and the manufacture of a modern miniature valve and the manual concludes with a series of typical circuit diagrams making use of "Osram" valves.

Conference on Heat Insulation.—The "Proceedings" of the conference on heat insulation, held under the auspices of the Joint Committee on Materials and their Testing, in conjunction with the Institution of Gas Engineers, at the Institution of Mechanical Engineers, London, on November 30, 1950, have now been published. These "Proceedings" embody the text of the following four papers presented at the conference, together with the full discussions:—"Heat Insulation in the Refrigeration Industry," by S. Richards; "The Economics of Thermal Insulation in Building Construction," by C. W. Glover; "High-Temperature Insulating Materials: Their Properties and Testing," by J. F. Clements; and "Medium-Temperature Insulation," by E. G. Cawte. Copies of the "Proceedings" can be obtained from the secretary of the Institution of Gas Engineers, 17, Grosvenor Crescent, London, S.W.1, at 13s. 6d. net.

Lecture Courses in Photoelasticity.—The Faculty of Engineering, University College, London, announces two forthcoming lecture courses in photoelasticity. The first consists of fifteen lectures and demonstrations on the practical application of photoelastic methods to the investigation of two-dimensional stress distributions. They will be given on Monday evenings, from 5 p.m. to 6 p.m., beginning October 8th, and the fee for the course is eight and a half guineas. The second course will consist of ten lectures and demonstrations on recent developments in the photoelastic investigation of three-dimensional stress problems. These lectures will be given on Monday evenings from 5 p.m. to 6 p.m., beginning February 18, 1952, the fee for the course being six guineas. It is stated that there are a few vacancies for students attending either of these courses to do practical work in the photoelastic laboratories, a fee of ten guineas covering one day a week throughout the session. Students wishing to attend the courses should communicate with the Secretary, University College, Gower Street, London, W.C.1.

Personal and Business

Ferguson Pailin, Ltd., states that its London office has been transferred to Bush House, Aldwych, W.C.2 (telephone, Temple Bar 8711).

Mr. G. C. Thew, A.M.I.E.E., M.I.R.S.E., has been appointed assistant signal and telecommunications engineer, North-Eastern Region of British Railways, York.

Mr. J. W. Bell, manager of the Dominions division of the Metropolitan-Vickers Electrical Export Company, Ltd., has retired. Mr. Bell has completed over forty-eight years' service with Metropolitan-Vickers.

The British Thomson-Houston Company, Ltd., announces the retirement of Mr. H. Trencham, M.I.C.E., M.I.E.E., consulting switchgear engineer at its Willesden works, after nearly thirty-six years in the company's service.

Gloucester Railway Carriage and Wagon Company, Ltd., states that its London office has been reopened, under the management of Mr. G. E. Embleton, at Albemarle House, 1, Albemarle Street, Piccadilly, W.1 (telephone, Grosvenor 8206).

The Department of the Engineer-in-Chief of the Fleet announces that Captain (E.) H. J. B. Grylls, R.N., is to assume, on October 15th, the duties formerly carried out by Captain (E.) L. A. B. Peile, D.S.O., R.N., as Senior Assistant Engineer-in-Chief (Technical).

Powell Duffryn, Ltd., states that its registered office is now at 19, Berkeley Street, London, W.1 (telephone, Grosvenor 3801). The premises at 40, Lime Street, E.C.3, are being retained as the company's City office, and the transfer office will continue at 17, Overton Road, Sutton, Surrey.

Mr. Frank Ellis, River Plate House, 12–13, South Place, London, E.C.2, has been appointed sole purchasing agent in London by the Rede Ferroviaria do Nordeste (R.F.N.) for its requirements in the United Kingdom and on the Continent of Europe. The R.F.N. is the successor to the Great Western of Brazil Railway, which was transferred to the Brazilian Government in September 1950.

The Minister of Local Government and Planning has appointed Sir Henry Prior, K.C.I.E., C.S.I., to be ironstone adviser to the Ministry. Sir Henry Prior's appointment follows from the passing into law of the Mineral Workings Act, 1951, which makes special financial arrangements for the restoration of land-worked opencast for ironstone, including the restoration of land left derelict.

British Patent Specifications

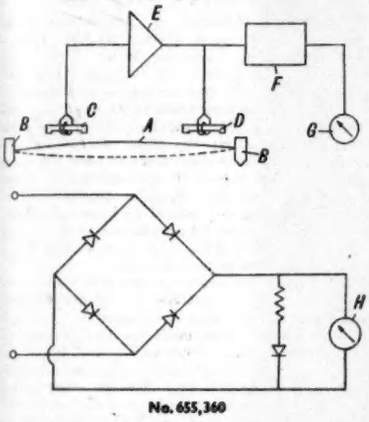
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

INSTRUMENTS

655,360. December 8, 1947.—Acoustic Strain Gauges, Muirhead and Co., Ltd., Elmers End, Beckenham, Kent, and William Clarke Lister, of the company's address.

In the measurement of mechanical strain, a method which has been widely used consists in measuring the change in the natural frequency of a wire stretched between two supports which are held in intimate contact with the surface under test and thus move with it. The object of the invention is to provide an improved apparatus for indicating



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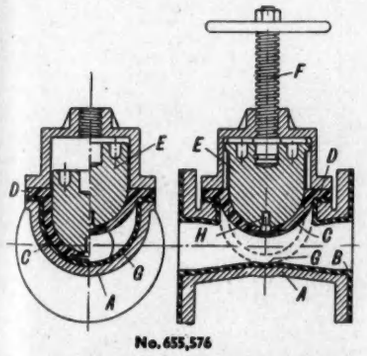
and/or recording the variation in frequency of the test gauge wire, and thus the strain under test. As shown in the upper drawing, the vibrating wire *A* is mounted between knife edges *B* clamped to the specimen. *C* and *D* are respectively the pick-up and excitation magnets and vibrations are maintained by means of the amplifier *E*. *F* is a frequency responsive network supplying an indicator *G*. The output of the amplifier may be fed through a compensating circuit shown in the lower view, consisting of four rectifiers arranged in a bridge, the output of which leads to the indicating or recording meter *H* which is shunted by a half-wave rectifier. The indicating meter may be replaced by or associated with a recording meter which may be a simple d.c. recorder suitably fed from a rectifier, or may be servo-operated in a case where both high sensitivity and quick response are required.—*July* 18, 1951.

VALVES

655,576. December 24, 1947.—Stop Valves, Adolf Ernest Kaufmann, 23, Old Burlington Street, London, W.1, a British subject.

As illustrated, *A* is the body of the valve, which is lined with a layer *B* of hard vulcanised rubber. The closing element consists of an interchangeable rubber membrane *C* of hemispherical shape with

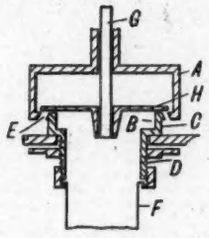


No. 655,576

an annular flange *D*. This membrane separates the closing means of the valve from the passageway through its body. The closing means consists of a cylindrical member *E*, operated by a screw *F* and having a hemispherical end against which the membrane is supported throughout the whole range of adjustment up to the point where it comes to rest upon the hemispherical seating *G*. A screw *H* which has its head vulcanised into the membrane, ensures to-and-fro movement of the membrane with the plug member. The thickness of the part of the membrane adjoining the flange is such that after stretching of the membrane on closing the valve, the uniformly even, fluid-tight joint against the upper surfaces of the valve body is maintained.—*July* 25, 1951.

655,012. October 25, 1948.—Liquid Discharge Valves, Pablo Forminaya Alonso, 2, Plaza Gomez Ferrer, Burjasit, Valencia, Spain.

The invention relates to a liquid discharge apparatus and is intended to ensure the complete discharge of a liquid contained in a storage vessel by making use of the energy produced by the movement of the liquid. As shown in the drawing, the bell *A* totally covers the outlet hole *B* and is supported so that it does not rest on the bottom of the tank, but is spaced from the periphery of a stepped extension *C* of a union *D* so as to leave a circular opening *E*. The union has the outflow tube *F* attached to it. The height of the



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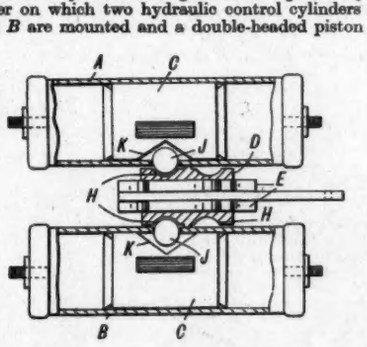
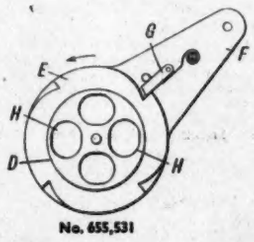
extension in the interior is slightly higher than the level of the mouth of the bell. When the passage or outlet *B* is opened by means of the rod *G* of the plug element *H*, the outgoing flow will commence, and the liquid will penetrate through the circular opening *E*, in the bell, rising slightly till it reaches the edge of the extension of the tube union, which forms the outlet, and is thus discharged. The rising flow which is formed in the interior of the bell presses against the body of the plug, pushing it upwards, keeping it in position and preventing it from falling on to the outlet hole as long as the liquid is flowing, until there is no more liquid left in the container. When the flow of liquid ceases and its action on the plug element comes to an end, the plug falls on to the opening closing it in readiness for a further cycle of operation.—*July* 4, 1951.

POWER TRANSMISSION

655,531. December 2, 1948.—Change-Speed Gears, John Ernest Wells, "Mount Pleasant," Welford-on-Avon, Stratford-on-Avon, Warwickshire.

As the accompanying drawings show, the ordinary cover of a synchro-mesh gearbox is replaced by a cover on which two hydraulic control cylinders *A* and *B* are mounted and a double-headed piston *C*





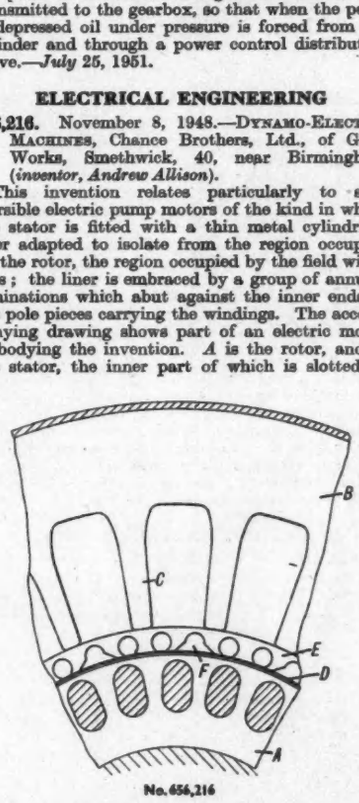
No. 655,531

is mounted in each cylinder. A gear selector is fixed to each piston and when the pistons are in a central position the gear is in neutral. When oil under pressure is fed into one end of the cylinder *A* the selector is moved to give the first gear ratio, and when the oil under pressure is fed into the other end of the cylinder, the selector is moved to give "reverse." The movement of the piston in the other cylinder *B* similarly moves the selector to engage second and third gear ratios. A neutralising device is mounted between the two cylinders and comprises a drum *D* having ratchet teeth *E* and a lever *F* mounted co-axially with the drum, the lever having a spring pawl *G*, so that on each movement of the lever in one direction the drum is given a quarter of a turn. Each face of the drum has four recesses *H* for receiving a ball *J*, forming a plunger, which is mounted in an opening in the wall of each operating cylinder. The centre of each operating piston has also a V-shaped recess *K*, which, when the piston is in the central position, registers centrally with the respective ball. When an operating piston is moved from a central position a ball *J* is moved outwards into a recess *H* in the neutralising drum; the inclined surface of the recess lying against the ball is such that if the neutralising drum is rotated the ball is forced away from the face of the drum and operates on an inclined face of the recess and returns the piston into a central or neutral position. A master hydraulic pressure supply cylinder is coupled to the pedal of the clutch through which the drive is transmitted to the gearbox, so that when the pedal is depressed oil under pressure is forced from the cylinder and through a power control distributing valve.—*July* 25, 1951.

ELECTRICAL ENGINEERING

656,216. November 8, 1948.—Dynamo-Electric Machines, Chance Brothers, Ltd., of Glass Works, Smethwick, 40, near Birmingham (*inventor, Andrew Allison*).

This invention relates particularly to submersible electric pump motors of the kind in which the stator is fitted with a thin metal cylindrical liner adapted to isolate from the region occupied by the rotor, the region occupied by the field windings; the liner is embraced by a group of annular laminations which abut against the inner ends of the pole pieces carrying the windings. The accompanying drawing shows part of an electric motor embodying the invention. *A* is the rotor, and *B* the stator, the inner part of which is slotted to



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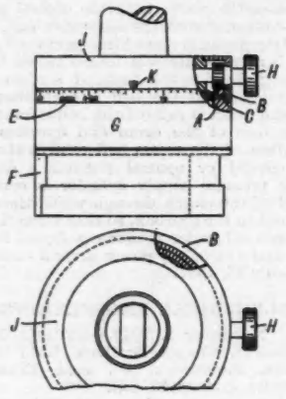
accommodate the field windings and to form pole pieces *C*. The region occupied by the rotor is isolated from the region containing the field windings by a thin metal cylindrical liner *D*, which is embraced by an assembly of annular magnetic laminations *E*, which abut against the inner ends of the pole pieces. As shown, there is formed in the inner periphery of each of the laminations *E*, at least one, but preferably a number of, equi-spaced shallow recesses *F*. Each recess is made of such a width as will allow the adjacent part of the liner *D* to bulge into it by expansion without risk of injury to the liner, sufficient depth to accommodate the expansion being provided. By the provision of the recesses described the liner is enabled to expand when heated without risk of injurious deformation.—*August* 15, 1951.

MACHINE TOOLS

655,796. December 21, 1948.—Calibrated Rings for Indicating the Amount of Cut in Adjustable Boring Heads, William Boneham, of "Culloden," Edwinstowe, near Mansfield.

The ring is located on a cylindrical seat and is slightly distorted in a plane at right angles to its axis so that it grips the seat when placed in position, and is readily adjusted relatively to its seat by removing the distortion of the ring by pressure across the appropriate diameter of the ring. As illustrated, the seat *A* on which the ring

B is located is made cylindrical, and a shoulder *C* is provided at one end of the seat to position the ring. The ring *B* is first turned so that the inner face is a working fit on the seat *A* and, after the outer face has been calibrated, the ring is squeezed so as to give it a very elliptical form. The ring is then placed on the seat by restoring it to its circular form by pressure applied at appropriate points. When the pressure is released the ring tends to return to its elliptical form and grips the seat. The slightly elliptical form provides a considerable area of contact between the ring and the seat, and the ring is securely held in position. The pressure points *E* on the ring are marked by serrations or in any other suitable manner so that



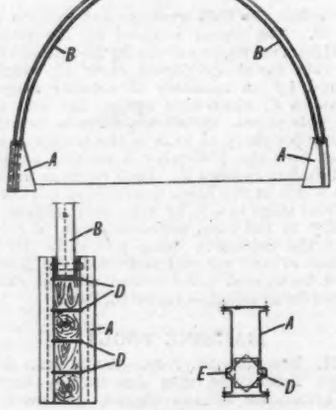
No. 655,796

pressure can be readily applied when it is desired to adjust the position of the ring relatively to its seat. With the boring head as shown in the drawings, the tool slide *F* is adjusted relatively to the axis of the head by holding the ring *G* stationary and turning the knob H, when the cap *J* is also moved relatively to the ring and the amount of movement imparted to the tool slide is indicated by the movement of the index mark *K* relatively to the graduations on the ring. When the finishing cut has been made on a hole, the ring *B* can be adjusted on the ring *G* to bring the zero mark into register with the index mark, and successive holes will be bored to the same size by operating the head in the normal manner until the zero mark registers with the index mark.—*August* 1, 1951.

MINING ENGINEERING

655,840. December 30, 1948.—YIELDING SUPPORTS FOR USE IN MINES, Dollery and Palmer (Pneumatic Tools), Ltd., 38, Victoria Street, London, W.1. *Communicated by Societe D'Etudes et de Recherches Industrielles et Minieres (S.E.R.I.M.), of 48, Avenue de la Bourdonnais, Paris, France.*

This invention concerns mine roof supports, and has for its object the providing of improved means for increasing the resilience of yielding roof



No. 655,840

supports by buffers made of wood. The upper drawing shows a gallery arch with an arrangement of wooden buffers according to the invention. The lower views show on a larger scale of the packing buffers for the foot, and a horizontal section of the foot of the arch. The arch comprises two feet or abutments *A* and strut members *B*, which bear at their upper ends against an apex joint member *C*. Within each abutment are arranged a series of four blocks of wood with interposed separating layers of iron plates *D*. In the constructional form shown, the two upper buffers are of deal, while the two succeeding buffers are of beech. The top buffer is arranged with its fibres or grain in the direction of the pressure, and the second buffer with its fibres or grain at right angles to that direction, while the next buffer is arranged with its fibres in the direction of the pressure and bottom buffer with its fibres at right angles thereto. The buffers and the plates can slide vertically within the abutment, so that when pressure is applied by the strut the top buffer will be completely crushed before any appreciable deformation of the succeeding buffers takes place, each block of greater rigidity acting like a rigid base until the preceding block is compressed up to complete exhaustion of its resilience. To ensure appropriate guidance for the intermediate plates *D* they are guided at their corners in grooves *E* formed in the sides of the foot or abutment. The arrangement may also be applied to a pit prop, the member *A* being replaced by the lower member of the prop and *B* by an upper prop member which can slide in the lower.—*August* 1, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Engineers' Guild

Thurs., Sept. 27th.—Caxton Hall, Caxton Street, Westminster, S.W.1, Annual General Meeting, 6 p.m.

Incorporated Plant Engineers

Tues., Sept. 4th.—LONDON BRANCH: E.L.M.A., Savoy Hill, W.C.2, "Storekeeping," J. Barrett, 7 p.m.
Thurs., Sept. 6th.—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, "Cutting Tool Dynamometry as an Aid to Machine Tool Maintenance," J. Purcell, 7.30 p.m.
Tues., Sept. 11th.—E. LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester, open meeting, 7.15 p.m.——GLASGOW BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Electronics in Production," 7 p.m.——S. WALES BRANCH: Institute of Engineers, Park Place, Cardiff, "Modern Applications of Rubber in Industry," 7.15 p.m.

Institute of Cost and Works Accountants

Tues., Sept. 4th.—St. Catherine's College, Cambridge, Second Summer School, "Factory Organisation," F. C. Lawrence.——*Wed., Sept. 5th.*—"Production Control, with Emphasis on Materials," Bruce A. C. Hills.——*Thurs., Sept. 6th.*—"Work Measurement," D. J. Desmond.——*Fri., Sept. 7th.*—"Fourth Element: A Case Study of the Overhead-to-Factory-Load Relationship," E. F. Brown.——*Sat, Sept. 8th.*—"Selection and Training," J. Munro Fraser.

Institute of Road Transport Engineers

Wed., Sept. 12th.—N.W. CENTRE: Visit to Hepworth and Grandage, Ltd., St. John's Works, Bradford, 2.30 p.m.——E. MIDLANDS CENTRE: Mechanics Institute, Nottingham, opening meeting of 1951–52 session, 7.30 p.m.

Institution of Works Managers

Tues., Sept. 4th.—WOLVERHAMPTON BRANCH: Works Visit to Goodyear Tyre and Rubber Company, Ltd., Wolverhampton, and John Thompson (Wolverhampton), Ltd.
Tues., Sept. 11th.—BIRMINGHAM BRANCH: Grand Hotel, Birmingham, dinner and annual general meeting, 7 p.m.

Royal Aeronautical Society

Mon., Sept. 10th.—Royal Institution, 21, Albemarle Street, W.1, 39th Wilbur Wright Memorial Lecture, "The Well-Tempered Aircraft," A. E. Raymond, Douglas Aircraft Corporation, 6 p.m.
Thurs., Oct. 4th.—Institution of Civil Engineers, Great George Street, S.W.1, Seventh British Commonwealth and Empire Lecture, "Air Transport in New Zealand and the South Pacific," Air Vice-Marshal Sir L. M. Isitt, R.N.Z.A.F., 6 p.m.

Stephenson Locomotive Society

Sat., Sept. 1st.—SCOTTISH CENTRES: Tour by special train over routes not usually available for passengers, Paisley—Johnstone—Barrhead. Start Paisley (East Mineral) about 2.45 p.m.
Sat. Sept. 8th to Sun. Sept. 9th.—Week-end tour of Motive Power Depots in Swansea and South Wales area.
Sat., Sept. 15th.— Visit to Ashford Locomotive Works and Running Shed, S.R., from 2.45 p.m.

EUROPE'S FIRST CATALYTIC CRACKING UNIT.—The first modern catalytic cracking unit in Europe has been completed at Pernis, near Rotterdam, by the Shell Petroleum Company, Ltd., and is expected to come into full operation shortly. The capacity of the new plant is 1,250,000 tons per annum, and this addition has raised the total capacity of the Pernis refinery to 5,000,000 tons per annum.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

RAILWAY SIGNALLING SYMBOLS: PART I, SCHEMATIC SYMBOLS

No. 376: 1951. Part I of this standard on schematic symbols has now been revised and is intended for use on general plans showing signalling requirements. The symbols do not show the component parts of the apparatus to be used.

In preparing the schematic symbols an endeavour has been made to provide for apparatus in general use, and they have been designed so that they may be combined with each other where one does not adequately represent the complete device.

The standard consists of the following sections:—signals, points, track details, apparatus, controls, level crossings and buildings. In it each symbol is identified by a reference number, and an alphabetical index is included. Price 5s., post free.

Technical Reports

Guide to the Selection of Aluminium Casting Alloys. General data sheet. ALAR Ltd., 3, Albemarle Street, London, W.1. Post free.—This guide has been rewritten in terms of the British Standard 1409 L.M. Specifications and deals only with the properties and characteristics of importance in selecting an alloy, more specific information being obtained from the data sheets listed on page 6. Cost classification has not been attempted, and the cheapest alloy does not necessarily produce the cheapest casting. Highest mechanical properties are generally obtained by heat-treatment, a process requiring special equipment, and increased costs must be allowed for this process while remembering the size limitations imposed.

Casting characteristics are discussed with reference to sand casting, gravity die casting, pressure die casting, fluidity and resistance to hot-tearing. The next section comments on the general properties of the casting alloys and special notes given concerning pressure tightness, corrosion resistance, machinability, weldability, density and thermal expansion. Mechanical properties are reviewed in the third section and guidance offered upon questions of tensile strength, proof strength, elongation, hardness values, fatigue strength, shock resistance and strength at elevated temperatures.

There are two tables; Table I gives the typical properties of the alloys when sand and chill-cast. Table II lists the casting characteristics and general and mechanical properties of the various alloys, indicating by a single letter their degree of suitability for the different casting methods linked with other associated properties. In both tables the B.S. 1490 specification is related to the older designation of the alloy.

Recommended Designs for Metal Arc Welded Mild Steel Building Structures—Beam and Column Connections. London: The British Welding Research Association, 29, Park Crescent, W.1. Price 2s. 6d.—This report gives examples of welded beam and column connections which are recommended as efficient and economical details for use in mild steel building structures on which the loading is nominally static, and where site connections are made primarily by means of metal arc welding. There are seven examples of "pin-joint" connections and twelve examples of "rigid-joint" connections.

Launches and Trial Trips

COPSEWOOD, coastal cargo ship, sister ship to "Eskwood." Launch, August 17th.

JEAN HELENE, motor trawler; built by Les Chantiers et Ateliers Augustin Normand for the Marine Marchande; length between perpendiculars 32m, breadth moulded 7m, depth moulded 4·05m; one four-cycle, single-acting, mechanical injection M.A.N. diesel engine, six cylinders, 450 h.p. at 207 r.p.m.

ESKWOOD, coastal cargo ship; built by the Burntisland Shipbuilding Company, Ltd., for the Constantine Shipping Company, Ltd.; length between perpendiculars 214ft 6in, breadth moulded 35ft 4in, depth moulded 16ft, draught 15ft 6in, deadweight 1600 tons; British Polar two-cycle, trunk-piston, airless-injection, direct-reversible diesel engine, cylinders 340mm diameter by 570mm stroke, 640 b.h.p. at 250 r.p.m. Launch, August 17th.

REGENT SPRINGBOK, motor tanker; built by the Blythswood Shipbuilding Company, Ltd., for the Bowring Steamship Company, Ltd.; length between perpendiculars 516ft, breadth moulded 70ft 6in, depth moulded 38ft, deadweight 17,600 tons; Rowan-Doxford two-cycle oil engine burning heavy fuel, five cylinders 670mm diameter by 2320mm combined stroke, 5600 b.h.p. on service, two single-ended horizontal multitubular boilers. Launch August 21st.